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The Canadian Research and Development Satellite Account, 1997 to 2004

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The Canadian Research and Development Satellite Account, 1997 to 2004

This paper highlights the newly constructed Research and Development Satellite Account (RDSA) developed by Statistics Canada. The RDSA provides an analysis for the capitalization of research and development (R&D) as proposed by international guidelines for the System of National Accounts. The account calculates several methods to measure the impact on gross domestic product of R&D expenditures. This paper presents the results of the RDSA for the years 1997 to 2004.

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The Canadian Research and Development Satellite Account: A preliminary study

Executive summary

It is widely recognized that the outcomes of Research and Development (R&D), similar to physical assets like machines, are used repeatedly and continuously in processes of production and therefore can generate returns over a period of time. These outcomes can also provide a store of value to those who own them. Therefore it is argued that these outcomes should be considered as assets as opposed to intermediate inputs that are used up in the period they are produced.

This study examines the impact of substantially broadening the treatment of R&D in the Canadian System of National Accounts (CSNA). This involves altering the treatment of certain R&D spending components from current expense to capital formation. Comprehensive estimates are developed for the years 1997 to 2004.

The definition of R&D used in this study is based on that of the Frascati Manual (FM) as published by the Organization for Economic Co-operation and Development (OECD). This includes freely available R&D.

Some R&D spending is already capitalized in the Canadian economic accounts (e.g., software). The paper focuses on the impacts on the economic accounts from the **additional R&D capitalization** but also presents the impacts from **total R&D capitalization**.

As measured by this report's base case, the **additional R&D capitalization** would raise gross domestic product (GDP) by 1.6% or $20.4 billion in 2004. Adding the impact from R&D activity already capitalized, it is estimated that the impact from **total R&D capitalization** is $34.6 billion of GDP in 2004 or 2.9% of total GDP.

Although the main focus of this study is the years 1997 to 2004, historical estimates were calculated back to 1976. This research indicates that R&D has become increasingly important to the Canadian economy. In 1976, total R&D represented 1.5% of GDP, considerably less than the 2.9% share in 2004.

As this is a preliminary study, various scenarios were calculated to indicate the possible range of impact depending on the assumptions used for valuation. For example, four scenarios for the rate of return of R&D were calculated. These scenarios resulted in the impact of R&D capital on GDP ranging up to $2.3 billion or 0.2% of the economy-wide GDP in 2004.

Introduction

1. Expenditures on research and development (R&D) play a key role in most modern economies including Canada. Organizations use R&D as a way to advance knowledge, develop new products or improve current products and production processes. In this regard, R&D spending is similar to investment in capital assets (such as machinery and equipment) since the benefits of the work can accrue over a period of time. While R&D is an intangible asset, it also provides a store of value and should be reflected in measures of wealth.

2. However in the *System of National Accounts 1993* (SNA93)–the international standard for the calculation of economic aggregates such as gross domestic product (GDP) and its underlying components and associated accounts–R&D spending has been treated as intermediate consumption rather than capital expenditure. Intermediate goods and services are used only once while capital assets are "used repeatedly or continuously in production processes for more than one year."[1] As a result, R&D's contribution to the economy is under-valued.

3. This issue had been previously identified by national accountants. SNA93 went as far as acknowledging that R&D spending was essentially investment activity. However, it was retained as intermediate consumption due to a number of perceived measurement difficulties including: distinguishing R&D activities from others in the production process; valuing R&D assets; and depreciating R&D capital to arrive at net stocks.[2]

4. Since then, a new set of recommendations have been put forward by the Canberra Group on the Measurement of Non-financial Assets. This group led the study of possible revisions to SNA93 on the measurement of tangible and intangible assets. In the forthcoming revised manual–SNA93 Rev1, R&D is recognized as an intangible capital asset with associated investment flows. This revised treatment was ratified by the United Nations Statistical Commission (UNSC) in 2007.

5. However, the adoption of R&D as an asset was accepted with the caveat that an implementation period was required to develop internationally comparable methods. This included consistent definitions of R&D as well as similar rates of depreciation and deflation methods.

6. A limited amount of research and development (R&D) activity is already capitalized in the Canadian System of National Accounts (CSNA). This study examines the impact of substantially broadening the capitalization of R&D in the CSNA and presenting the results in the form of a satellite account. The purpose of the Research and Development Satellite Account–aside from an impact study–is to act as a bridge towards the next historical revision of the CSNA. At that time, the CSNA will assess and implement SNA93 Rev1 and plans to expand the definition of capital to include all identifiable forms of R&D.

7. This study is an assessment of R&D data issues and options that are presented in a CSNA context, but also more generally. It also provides an initial set of estimates detailing the impacts of this change on the sequence of accounts.

8. This paper starts by examining the definition of research and development relative to the conceptual framework of the System of National Accounts (SNA). It then outlines the current treatment of R&D in the Canadian system. This is followed by an examination of the data sources behind the Research and Development Satellite Account (RDSA), followed by a description of the methodology used. The proposed methodology focuses on issues of valuation, depreciation and pricing of R&D capital. Measurement issues concerning inventories as well as inclusion in wealth estimates are also discussed. The role and structure of satellite accounts are summarized in the context of the sequence of accounts. A results section then follows. The paper concludes with a summary and suggestions for future work leading to the next historical revision to the CSNA.

1. *Guide to the Income and Expenditure Accounts*, catalogue 13-017, Statistics Canada (forthcoming).
2. See paragraph 6.163 in *System of National Accounts 1993*.

Definitions and conceptual issues

9. There are two fundamental and related issues facing economists and national accountants with respect to measures of research and development. First, what is the content and scope of R&D; and second, at what point does R&D become an asset in the economy. To initiate this discussion, it is useful to consider the description of an asset.

Definitional issues

10. SNA93 defines an asset as entities functioning as a store of value: a) over which ownership rights are enforced individually or collectively and b) from which economic benefits may be derived by the holder or user over a period of time. The characteristics of R&D seem to fit this definition closely in that it acts as a store of value which can be purchased and sold. Ownership rights can be enforced, although at times, it can be provided freely to the public. R&D also acts as an asset in that benefits may derive from it over a period of time.

11. There have been competing visions of, and some degree of controversy with respect to, how R&D and its sub-components should be defined in the national accounts. The most common starting points for these discussions come from SNA93 and the Organization of Economic Cooperation and Development's (OECD) Frascati Manual[3] (FM).

SNA93 definition

12. SNA93, which has been the standard for the national accounts since the early 1990s, focuses on R&D with respect to in its role in production. It refers to research and development as "an activity undertaken for the purpose of discovering or developing new products, including improved versions of qualities of existing products, or discovering new or more efficient processes of production".[4] It goes on to state that R&D is "undertaken with the objective of improving efficiency or productivity or deriving other future benefits." [5] This is a broad definition in that it could include both the efforts involved in the initial design of a product as well as new production and marketing costs. This concept more closely matches that of innovation. It points to a goal of improving efficiency, productivity or other future benefits. However the SNA93 definition would seem to exclude research done for non-commercial purposes or with no immediate productive use. Further, SNA93 stopped short of including it in the asset boundary and therefore R&D assets remain excluded from most countries' national accounts' statistics.

The Frascati definition and SNA93 Rev1

13. Upon the recommendation of the Canberra Group on the Measurement of Non-financial Assets, the UNSC has decided that the definition set forward by the Frascati Manual (FM) be used as the updated SNA description of R&D in the national accounts. This definition states that:

> "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including the knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."[6]

14. Research is further classified by the FM into three types. **Basic research** is work done without any direct application immediately in sight. This work may or may not be patented or used for commercial purposes at a later date. Research done in universities or by government may often be of this nature. **Applied research** is original

3. The Frascati Manual is a product of the OECD Working Party of National Experts on Science and Technology Indicators (NESTI).
4. SNA93, Paragraph 6.142.
5. SNA93, Paragraph 6.163.
6. Frascati Manual, OECD 2002, paragraph 63.

work but done for a specific purpose. Because of its focus, this work often ultimately contributes to production. **Experimental development** is work that draws on previous or existing experience to produce new systems or products or to substantially improve existing processes or products.

15. In some ways the FM definition is broader than the original SNA definition in that all basic research is included. This would include research that focused on scientific novelty with an aim to furthering knowledge. This R&D may be freely available to the public and may have no enforcement of ownership rights.

16. Conversely, the FM view is narrower than the SNA93 in that costs associated with new production (e.g., manufacturing scale up and new marketing initiatives) are not included. Yet the overlap between the two definitions is significant.

17. Notably, the SNA93 Rev1 states that R&D does not extend to including human capital as assets within the System.[7] The guidelines recommend that R&D that provides no economic benefit should be excluded from R&D assets, thereby departing from the FM definition. Since much of R&D is produced on own-account (remains within the organization that produced it), it goes on to suggest that R&D could be valued at cost.

The scope of research and development

18. The scope of R&D is a key issue when considering capital formation since the aggregate value of R&D varies considerably depending on where the R&D boundary is drawn.[8]

19. SNA93 Rev1 initially suggested that freely available R&D not be included as an asset. However, it went on to state that as a result of measurement issues, and the fact that it usually does not comprise a large portion of R&D expenditure, it could be included with little impact on the total. The reasoning for the exclusion of this research was that there was no guarantee of exclusive benefit of this information. The research, once completed, provided no market advantage and therefore was not an asset for any sector.

Research and development definition summary

SNA93 – production related

FM – three types of R&D (basic, applied and experimental development)

SNA Rev1 – adopted FM definition

20. In this study, freely available R&D is included as an asset and is allocated to the balance sheet of the originator until it becomes obsolete. This decision was taken because the originator of the research may have some loose ownership rights of any unrealized economic benefits. In the case of government funded R&D, societal ownership is also possible. Also, the national accounts definition of an asset is linked to ownership rights and not market advantage. Further, it is included because this R&D still provides economic benefits to society. A practical concern also exists as there is no data available that allows the separation of these expenditures from the rest of R&D in the Canadian statistical system. Data is available for basic research but this is not equivalent to freely available R&D.[9]

7. The issue of asset boundaries is complex and much discussed by national accountants, particularly when dealing with intangible assets. Human capital is one of these issues. In the SNA, human capital is not treated as an asset. "Ownership rights" in connection with people as well as valuation of this capital, pose difficult issues with this matter. Further, human capital does not fit neatly into the SNA framework, as it straddles the line between labour and capital factors of production.

8. Baldwin *et. al.* (2005), in their study of productivity, contend that intangible assets should include other innovation costs, such as product design and marketing, thereby providing a more valid comparison between the Canadian and the U.S. economy. The study indicated that with this broader definition, Canada's R&D costs would more than double those based on the FM definition.

9. Since some data exists for patented research it has been suggested that non-patented research could be used as a proxy for freely available. However, for some industries, non-patented R&D is not freely available.

Table 1 Scope of research and development in Canada

		Research and development to be capitalized			
				Future economic benefit	
Type of activity	**Example**	**Successful**	**Unsuccessful**	**Discernible**	**Indiscernible**
Basic research	Research to create different types of plastic	SNA Rev1 - included CSNA - included	SNA Rev1 - included CSNA - included	SNA Rev1 - included CSNA - included	SNA Rev1 - excluded CSNA - included
Applied research	Research to find plastic that withstands cold temperatures	SNA Rev1 - included CSNA - included	SNA Rev1 - included CSNA - included	SNA Rev1 - included CSNA - included	SNA Rev1 - excluded CSNA - included
Experimental development	Using cold resistant plastic in production process	SNA Rev1 - included CSNA - included	SNA Rev1 - included CSNA - included	SNA Rev1 - included CSNA - included	SNA Rev1 - excluded CSNA - included
Innovation	Costs associated with marketing new product	SNA Rev1 - excluded CSNA - excluded	SNA Rev1 - excluded CSNA - excluded	SNA Rev1 - excluded CSNA - excluded	SNA Rev1 - excluded CSNA - excluded

Note: SNA Rev1 refers to the proposed treatment in the new international SNA guideline. CSNA refers to the treatment in the Research and Development Satellite Account.

21. The freely available issue is closely related to that of spillovers. Spillovers arise when the benefits of R&D accrue to units other than the owner of the R&D. This may occur when the R&D is freely available or when a patent matures. Spillover benefits could be realized by users. However this study makes no attempt to measure spillover benefits. Measurable benefits remain with the originator of the R&D.

22. The treatment of unsuccessful R&D can also be debated. For example, should research that registered no productive result be included in the estimates? The fact that the cost of unsuccessful research is incorporated in the cost of products would seem to argue for its inclusion. Further, unsuccessful tests are useful in that they bring the search process closer to success. These tests may also bring other unexpected results since other products are occasionally developed from them. An example of this occurred in northern Canada where while searching for oil, large diamond deposits were found. In this study, unsuccessful research expenditures are capitalized.

23. The SNA Rev1 also indicates that R&D that is not sold and does not provide a future economic benefit should not be included as an asset. However, in light of the discussion of unsuccessful research and considering the societal benefits the R&D may provide, it is difficult to discern which R&D does not provide eventual economic benefits. No attempt was made to discern or measure the R&D that does not have future economic benefits in this study.

Research and development: intangible produced assets

24. There are several different types of assets defined in the SNA93. Distinctions are made between produced and non-produced assets and also tangible and intangible assets. R&D is a produced asset unlike naturally occurring assets such as land and mineral deposits. Since it is not physical in nature, like a machine, R&D is defined as intangible. In the SNA, intangible assets include mineral exploration, computer software, databases and entertainment, literary or artistic originals. These are all distinct from each other and from R&D.

25. The treatment of intangible assets in the SNA93 was incomplete but after the Canberra Group deliberations and in SNA93 Rev1, there is a much better coverage of intangible assets in both production and wealth. Further, the SNA93 Rev1 states that with the inclusion of R&D within the asset boundary, patents and copyrights will no longer be identified specifically, but rather they will be included in R&D assets.

Stock-flow issues specific to research and development

26. The nature of R&D intangible assets brings forward some conceptual issues not common to other categories of capital. While investment flows that contribute to the stock of capital are relatively easily defined, the rate at which R&D assets are used up in production and transactions in existing R&D assets are less straightforward to measure.

27. R&D capital may not be used up gradually over time like machinery and equipment. It can become obsolete very quickly (e.g., some software R&D) or it can have a long service life (e.g., pharmaceutical R&D). This makes it more difficult to consider the nature of the depreciation of the stock in relation to average services lives, and about what should be included in the stock of capital.

28. Sales of R&D also present a unique issue. When R&D assets are sold by a business, there is a question of whether this reduces the stock of that entity's outstanding R&D capital. In one sense, it does not necessarily alter the stock of accumulated knowledge available to that company. However, the company may have sold certain user rights associated with the R&D capital (patents/copyrights) which would prevent them from using the knowledge in production. On the other hand, the company may have simply sold a service flow associated with the original R&D or even an offshoot of the original R&D. On the latter point, a software producer generally does not sell R&D but rather software produced using a stock of accumulated R&D.

29. From an economy-wide point of view, the impact of imports and exports of R&D on the stock of R&D capital needs further consideration. Specifically, does the stock of R&D capital in national wealth increase with business purchases of R&D from abroad and decrease with sales to non-residents? If the trade in R&D is with affiliates, it becomes an even more difficult issue to sort out.

30. Furthermore, an increase in demand for R&D assets may contribute to a rise in the value of R&D capital through a price effect, though this effect might be difficult to capture. The value of business R&D capital would most certainly be reflected in the market value of the firms engaged in R&D activities.

31. In this study, R&D that is sold is considered to be no longer in the stock of the seller but is completely transferred to the purchaser. This is the case for both domestic transactions as well as for exports of R&D. This method was chosen for practical considerations as well as the fact that it matched the U.S. method. This treatment requires further consideration. When R&D is purchased either domestically or from an international source, it is considered as a purchase of fixed capital formation and not as an input (intermediate expense) for production.

Existing estimates of research and development capital in the Canadian system

32. Several types of intangible assets are already included in the CSNA estimates, including software development and mineral exploration. Some software R&D is encompassed in total investment in software, which was capitalized in the Canadian SNA in 2001.[10] Mineral exploration has been capitalized in the accounts since 1997 as part of the revision to incorporate the SNA93 recommendations.

33. Software capitalization was introduced into the CSNA in 2001. Three types of software were included: pre-packaged, custom-design and own-account. Own-account software was defined as that done "in-house" by employees for use within an organization. This includes work defined as R&D in the FM data and, if not taken into account, could lead to a potential double-count.

10. See Chris Jackson, "Capitalization of Software in the National Accounts", Statistics Canada, 2002

34. Not all purchases or costs related to software acquisition were included as investment when software capitalization was introduced into the CSNA. Expenditures on repair and maintenance, spending on employees' training on software, purchased software that would be embedded in hardware and then re-sold and the costs of developing software that would be later sold (not used in-house) were all excluded from software investment spending. The last exclusion (costs of developing software for later sale) is clearly R&D expenditure.

35. It is important to note that R&D on software and the actual software development create two distinct assets. Any mixing of these assets in the CSNA is the result of measurement issues. The R&D acts as an "intellectual machine" in the making of the software. Therefore, the R&D is capitalized by the producer of the software, while the software itself is capitalized by the purchaser of the software. For own-account R&D on software, the producer is also the purchaser.

36. To avoid a double count with software capital some of the software R&D as measured by the FM data, should be excluded from the R&D estimates, namely R&D on own-account software. However, data sources do not provide any distinction between whether the R&D work was done for in-house purposes and therefore already included in software capitalization or if it was being developed for resale and therefore to be included in R&D.[11] In an effort to overcome this issue, all R&D expenditure undertaken by the software development and computer systems design industries North American Industrial Classification System (NAICS 5112 and 5415) were included in the R&D estimates. The assumption being that this expenditure was for R&D to support the development of software that was not in-house, but rather to be sold. All other software R&D spending (for all other industries) was considered to be for in-house purposes and therefore assumed to already be included in software capital.

37. In the case of mineral exploration, the costs associated with both successful and unsuccessful exploration are currently included as capital in the CSNA. The rationale for their inclusion as capital is that valuable knowledge regarding subsoil assets, and related to the eventual extraction, is gained from either process. These mineral exploration costs are not the same as the expenditure on R&D by mining companies as found in the FM data in Canada. The R&D expenditures from the FM data are aimed at improving the mining process, including exploration as well as other production.

38. Before the SNA 93, most spending on mineral exploration was already capitalized in the Canadian SNA. However, general exploration expenditures undertaken by a mining company on own account or by a mineral exploration company on contract, as well as geological and geophysical expenses incurred in the exploration of petroleum and natural gas were not capitalized. With the historical revision in 1997, all exploration expenditures as well as geological and geophysical expenditures were capitalized. As a result, spending on mineral exploration is not included in the estimates of R&D capital since these are intangible assets that are uniquely different than R&D. Conversely, R&D undertaken for the mining sector is not included in the exploration costs and therefore is included in the R&D expenditures.

Data sources for other research and development components

39. One of the long-standing issues with adopting and implementing the treatment of R&D as capital in the national accounts has been the perceived problem of data availability. Fortunately, an internationally recognized information set estimating R&D expenditure already exists. The compilation of these data, as detailed by the Frascati Manual, was initiated by the National Experts on Science and Technology Indicators (NESTI), a working group of the OECD. The Frascati expenditures provide information on R&D expenditures, organized by funding and performing sector.

11. The software capitalization estimates were not based on FM data but rather were calculated using labour force information related to programmers and engineers working on software development.

Basic data sources in Canada

40. Statistics Canada's Science, Innovation and Electronic Information Division has produced data based on the FM for the years 1963 to the present.[12] The data are referred to as Gross Domestic Expenditure on Research and Development (GERD). These expenditures provide a solid basis for measuring R&D output and investment. Information is collected using both surveys and administrative sources. Surveys cover the business sector units with over $1 million of R&D expenditures, whereas tax data are used for firms below this threshold. Business sector data are available at a detailed industry level for basic, applied and developmental research. A combination of survey and administrative data are also used to compile data for government and its sub-sectors (which includes higher education).

Sectors and industries

41. An issue that has been noted in several international studies concerning R&D capital formation has been that of linking the FM sectors with SNA sectors (Table 2).[13] This sectoring issue does not present a complicated problem in the Canadian case. For business enterprises, the FM data is available at a detailed industry level and therefore a split between financial and non-financial industries-sectors is not difficult. Source of funding information is available for the private non-profit sector.[14] Higher education is assigned to the general government sector in Canada.

Table 2 Linking Frascati Manual sectors to System of National Accounts sectors

Organisation for Economic Corporation and Development Frascati Manual	System of National Accounts
Business enterprise sector	Non-financial corporations
	Financial corporations
Government sector	General government
Private non-profit sector	Non-profit institutions serving households (NPISH)
	Households
Higher education sector	Corporations and quasi corporations
	General government
	Non-profit institutions serving households (NPISH)
Abroad	Rest of the world

42. In calculating the production account in the RDSA in Canada, a similar classification issue arises. It involves mapping the industry FM data to the industry detail used in the Input-Output Tables (IOT) in the SNA. This process does not change the levels of expenditure. Both FM and SNA are based on NAICS, however the SNA tables introduce some aggregations not found in NAICS. A well-defined concordance between NAICS and the IOT allows for a relative easy conversion of the industry data.

12. Survey 4201, *Research and Development in Canadian Industry* is an example of one of several surveys undertaken to gather R&D statistics at Statistics Canada.

13. Carol Robbins, *Linking Frascati-based R&D Spending to the System of National Accounts*, 2006.

14. In the CSNA, the private non-profit sector is entitled persons and unincorporated business, and is not split any further.

Other System of National Accounts adjustments

43. Additional adjustments are required so that the FM expenditures conform to the framework of the national accounts. These adjustments transform the expenditure-based (or cost-based)[15] FM data to an output measure as defined in the SNA. Most of the adjustments for Canada are based on data from within the SNA, and are as follows:

- Data from the Input-Output Tables (IOT) are used to estimate other taxes on production and net operating surplus.
- Data for subsidies are found within the FM framework.
- Export and import data are available from the FM accounts but are supplemented with data from the Balance of Payments (BOP) for exports and imports of R&D services. Transactions in existing R&D assets are not considered in this study.
- Price data were available from the IOT and from Prices Division in Statistics Canada for inputs of labour and other expenses.

44. The FM data overlap with capital expenditures on computer software that are already in the CSNA. Because of the growing importance of other intangible assets to the economy, keeping software expenditure separate from other R&D expenditure seems the preferred treatment. This implies that other R&D would be its own commodity in the IOT, and distinguished from software development. Mineral exploration, another intangible asset, also remains separate from R&D. However R&D done by the mining sector, which is not included in the exploration costs, is part of R&D expenditures. By removing software from the FM based R&D expenditures, the total FM R&D estimates for Canada are reduced by 4.2% in the 2004 reference year.

Data issues

Required input-output system detail

45. Several data issues arise with the use of Frascati data in Canada. One involves the "other current costs" data in the FM database. Total FM expenses are split into expenditure on wages and salaries, capital spending and other current costs. Information is not available on what these other current costs are but this more detailed data is required to allocate inputs in the Input-Output (IO) system. The other current costs comprise approximately one-third of total costs. One option would be to consider expanding the R&D surveys to include questions relating to these costs.

Imported research and development

46. One data concern relates to the scope of the R&D data from FM sources. The FM surveys include only producers or funders of domestic R&D. However, when non-producing units import R&D, these expenditures are not included in the FM data. For example, a company may not do any R&D of its own in Canada but may contract for R&D activities from another country. Since they are not producers of R&D they would not be in the scope of the Canadian FM-based surveys. However, these cross border purchases are collected through the Balance of Payments surveys and added to the import totals.

The **higher education sector** is an FM construct that includes: all universities, colleges and post-secondary education no matter their source of financing or legal status. It also includes research institutes and stations or clinics operating under or in association with higher education institutions (see page 68 of the FM).

15. As denoted by SNA93 Rev1.

Multinational enterprises and exported research and development

47. A complicating issue involves data from multinational enterprises (MNEs). These companies can distribute the findings of their research across borders with little or no indication as to where the R&D was initially undertaken and where the R&D is eventually used. The Canadian practice for measuring R&D in international trade data include the use of tax records to help discern the flow of R&D across borders. Canadian firms have an incentive to report their R&D spending, since they receive tax benefits for these expenditures. The impact of these flows of international transactions on the level of the capital stock is an issue which still requires further investigation.

Multi-provincial corporations

48. A similar issue also exists in measuring regional data in Canada. Multi-provincial corporations, with R&D activity in several provinces or production units in other Canadian locations than their R&D unit, create measurement issues across provincial boundaries. Provincial data in this study are not adjusted for these trade flows. Further research is required to determine whether data is available for an adjustment to the data for these flows.

Post-secondary research and development estimates

49. One possible weakness of the Canadian FM information is that the higher education data is collected through a combination of administrative information and an estimation model. The model, necessarily, requires several assumptions in its estimation process. An example of this is data carried forward from a faculty time use survey undertaken in 1998-1999. Whether the estimates for time use are still valid is not known. An updated study on faculty time use would answer the question regarding the quality of this data.[16]

Producers and funders of research and development

50. The FM data available in Canada provides information on both the funder and performer (or producer) of the R&D. General government, not including universities, funds more research than it undertakes and therefore the distribution of ownership affects flows and stocks within the accounts. The allocation of the data amongst sectors could also affect productivity since, currently in the CSNA, government output does not include a full return to capital.

51. The performer (intramural) estimates in the Canadian FM data are considered of higher quality than the funder statistics (extramural expenditures)[17]. This is because the performer is the unit that is surveyed. The performer also has more precise information of how and when the money was used. For example, the performer may not use the full amount of funding in a given year or may have a different financial year than the funder.

Basic prices refer to the amount received by the producer from the purchaser of a good or service produced as output net of taxes and subsidies on products.

52. In this study, calculations are based on the performer (producer) of the R&D for the production account. The data were then adjusted for exports, domestic sales, imports and domestic purchases so that in the sector accounts, the final owner of the R&D was attributed with the investment flow. In most cases, the performer of the R&D is also the owner. However, depending on the nature of the contract between the performer and funder, ownership rights may be shared between the two parties. This is an important distinction since in the National Accounts an asset is allocated to the sector of the owner.

16. Canadian R&D data are generally divided into natural sciences and engineering effort and social sciences. For the business sector, R&D data is only collected for natural sciences and engineering. R&D for social sciences undertaken by the business sector is therefore missing. No adjustment is made in the study for this data gap.

17. The FM data is organized by intramural and extramural expenditures. Intramural expenditures are those performed within a unit no matter the source of funding. Extramural expenditures are those paid to another unit for R&D services.

Measurement issues and methodology

53. There are several measurement issues that surface in the creation of an RDSA. These include calculating output (valuation), inventory accumulation (allocation), depreciation (measuring the service lives of R&D) and deflation (calculating real estimates). Each will be discussed in turn.

Calculating output (valuation)

54. Estimates of output can be established from the FM data that would be measured at basic prices. However, since the FM captures only R&D *expenditures* (or at cost as denoted by the SNA93 Rev1), a method has to be developed to estimate the *output* of R&D.

55. The issue of valuation is not straightforward since the majority of R&D is undertaken on own-account (in-house) and therefore is never directly sold and no market price exists. One step used to transform the FM data to an output concept involves estimating a rate of return which would typically be reflected in a market sale of an asset. The return is also known as the net operating surplus.

56. An alternative, as suggested in the SNA93 Rev1, would be to measure R&D at cost. Net operating surplus would then not need to be calculated. However, the value of R&D would not be comparable with other assets in the SNA that are based on output values at basic prices. It would also not quantify the value of transacted R&D sold.

57. Is adding operating surplus to the expenditure data the correct treatment for **own-account R&D** which is not sold? It could be argued that the unit collects the benefits from this R&D through the prices received on the market for the products the related R&D was instrumental in producing. It would then follow that no rate of return should be added to the R&D expenditures as this would lead to a "double-count". However, the production of the R&D and the use of the R&D asset to produce goods or services are in different periods. Also, if no return was directly added, the valuation of the R&D would change depending on whether the R&D was performed on own-account or whether it was bought from another unit. This could imply changes to the size of an economy if a structural shift away or towards own-account R&D occurred, which is not a desirable feature of measures of economic activity.

58. Calculating the output of R&D at cost for own-account producers would suggest including labour costs and other intermediate expenses as well as capital costs but excluding net operating surplus (and thereby excluding business profits). The cost data are known and therefore relatively straightforward to calculate. On the other hand, the data for a rate of return are not available from the FM data. A similar issue is encountered in the CSNA with own-account construction. The treatment for construction has been to value the investment at cost.

59. A further consideration is that the inclusion of a return for R&D would result in the reallocation of surplus from the activity related to the R&D to the actual R&D activity. This, in turn, would affect productivity measures since an activity may have a higher productivity measure because it includes a return that rightfully should be allocated to R&D.

Rates of return

60. If operating surplus is deemed essential for R&D, the issue then becomes one of how to establish a rate of return. In a perfect market, R&D would trade at the price that approximates the discounted value of the future stream of income it would generate. However, this information on market prices and therefore on rates of return is not available and therefore an estimation method is required.

61. The U.S. satellite account used a return of 15% based on the average of many different studies done in the U.S. This rate was higher than that of other assets. In a previous study completed by Statistics Canada[18], the rate of return used was equal to that in the R&D industry North American Industrial Classification Systems (NAICS) 5415, Computer Systems Design and Related Services and 5417; Scientific Research and Development Services on R&D sold.

62. This study calculated four scenarios for estimating the rates of return. One scenario assumed no operating surplus, except for consumption of fixed capital (CFC), for own-account R&D. [19] Further, it used the rate of return of the industry in which the R&D was performed for *R&D sold* to other units. This method is similar to the one used in the first Statistics Canada study but differs in that the rates of return used are specific to each industry rather than the rate of return for the R&D industry. This scenario provides the base case for this study and all results refer to this case, unless otherwise specified. It was chosen as the base case since it is an approach similar to the U.S. method and corresponds to the "cost approach" as recommended by the SNA Rev1 and the data is available from the FM source.

63. Based on the work in the U.S.[20] and elsewhere, three other scenarios were established. In these cases, a return was added whether the R&D had been sold on the market or if it was used in house by the producer. One scenario used the rate of return of the industry in which the R&D was performed for all R&D. The other two scenarios added a premium to this rate of return to reflect the higher profits generally received by R&D intensive companies. The two premiums added an additional 5% and 10% to the industry return. The addition of a rate of return was also assumed by Mandler and Peleg[21] in their work on bridge tables.

64. The calculation of net operating surplus is restricted to the business sector. For the government and the non-profit sectors, output equals operating costs (including CFC), following the National Accounts' convention.[22]

Other adjustments to calculate output

65. Transforming FM data to SNA output requires several steps beyond that of adding a rate of return.[23] Table 3 illustrates the adjustments required and their magnitude in the Canadian SNA.

18. Siddiqi and Salem, *A Proposal for Treating Research and Development as Capital Expenditures in the Canadian SNA*, Statistics Canada, June 2006.
19. CFC is known as capital consumption allowance (CCA) in the Canadian Accounts. CCA is dominated by consumption of fixed capital (depreciation) as well as some small miscellaneous valuation adjustments.
20. Bureau of Economic Analysis, R&D Satellite Account: Preliminary Estimates, September 2006. See also Ram Acharya, *Own and Total Economy Returns to R&D: How Different Are They Across Industries?*, Industry Canada, December 2006.
21. Mandler and Peleg, *Background and Issues Paper for the R&D-SNA Taskforce*, Voorburg, April 2003.
22. The new SNA guidelines may recommend that a return to capital also be added to government activity.
23. Considerable work has been done in creating bridging tables for R&D capitalization. Carol A. Robbins' paper *Linking Frascati-based R&D spending to the System of National Accounts* March 2006 provides a detailed account of the bridging procedure.

Table 3 Reconciliation between FM data and Research and Development Satellite Account, 2004

	millions of dollars
Frascati Manual survey data	26,003
Coverage	
Capital expenditure	-1,600
Subsidies on production	-107
Software	-993
Valuation	
Net operating surplus	340
Capital consumption	1,346
Other taxes on production	184
International trade	
Export adjustment	780
Total research and development produced in Canada	**25,953**
Exports of research and development	-2,999
Imports of research and development	1,270
Additional research and development capital investment	**24,224**

66. Output includes labour and other current costs, and these expenses are defined in the same way in the National Accounts as in the FM estimates. The FM data also include capital expenditure on land, buildings and machinery and equipment. To calculate total output, estimates of depreciation of this capital are required.

67. To depreciate the capital costs, a Perpetual Inventory Method (PIM) was used. Land was excluded from the calculation. Since detailed information of the capital used in the production of R&D was not available, certain assumptions were made. Asset lives for government and non-profit capital stock were set at ten years. Asset lives for business capital were set equal to the asset lives of the industry in which the R&D was performed. Since the consumption of fixed capital estimates are included as costs in the production of R&D, they are included as part of the investment on R&D.

68. An adjustment also was made for subsidies paid by the government for R&D. A subsidy, as defined in the SNA, is an unreturned payment given by a government unit to a business for production based on the levels they produce, sell or import. This is different than a government paying for R&D work on a contract basis. The FM data provide the details to remove subsidies from the expenditure estimates by industry.

69. The FM estimates do not include other taxes on production. Therefore an adjustment is required to value R&D at basic prices. Taxes were calculated by using the tax rate for each Input-Output (IO) industry and multiplying this by the R&D output in that industry.

70. Two sources of data, those published by Balance of Payments (BOP) and those produced by the FM system, are available for the measurement of international trade of R&D. These estimates are collected from different sources and measure theoretically different values and therefore are not equal. FM data measures the expenditures in creating R&D while BOP export data may include a margin. A reconciliation procedure was undertaken to match trade data for all industries. FM expense data were increased to reflect these new totals as the difference was considered under-coverage in output. Thus, production, investment and exports were all

increased as a result of this export adjustment (see Table 3). It should be noted that the BOP and FM international trade data did differ in level; however both sources indicated the same trend as well as a net trade surplus for R&D expenditure for all years in the study.

Supply and use of research and development

71. To implement the change in treatment of R&D in the SNA, a full supply and use framework must be developed. The supply of R&D originates either from domestic production, R&D purchased in Canada or from imports of R&D services.

Table 4 Research and development supply and use, 2004

System of National Accounts Sector	Supply of research and development				Uses of research and development				
	Research and development produced in Canada	Imports of research and development	Research and development purchased in Canada	Total supply	Domestic sales of research and development	Exports	Fixed capital formation	Inventories[1]	Total use
	millions of dollars								
Business	15,029	1,270	1,025	17,324	393	2,890	14,041	0	17,324
Government	10,816	0	3,652	14,468	4,910	96	9,462	0	14,468
Non-profit	108	0	696	804	70	13	721	0	804
Total	**25,953**	**1,270**	**5,373**	**32,596**	**5,373**	**2,999**	**24,224**	**0**	**32,596**

1. Not calculated.

72. Once the supply of R&D produced is established, the uses of R&D can be considered. R&D can be exported, sold within Canada or used as capital in domestic production. The domestic capital or gross fixed capital formation (FCF) needs to be valued at market prices, thereby matching the valuation of other FCF estimates.

73. A reconciliation process was undertaken for domestic sales of R&D between sectors in the economy. By definition, total domestic sales and purchases from all sectors in the economy should be equal. However these two data series are not reconciled within the FM data system at the industry level. The reconciliation process was done for each industry within the business sector, for all government sectors, including the federal and provincial government and universities, as well as the non-profit sector in the RDSA. The FM "performing" data are considered more accurate than the "funding" data and therefore were used as the benchmark.

74. In the present study all purchases of R&D, whether from a domestic source or internationally imported, are considered as final R&D expenditure and not an input into other R&D work. Therefore, by capitalizing these R&D expenses, intermediate expenses will decrease by the total of these purchases. No information regarding the use of the purchased R&D is available on these transactions however this treatment mirrors what was done in the CSNA for software capitalization. This assumption does not affect the level of R&D investment.

Calculating gross domestic product

75. The previous steps calculated the supply and use of R&D including the amount of R&D investment or FCF to be added to the final expenditure. Three more steps are required to calculate the adjustment to GDP in the core accounts.

76. The first step involves an adjustment for the spending of government and non-profit institutions. R&D expenses for these sectors are already included as current expenditure in final expenditure. Therefore the change in treatment of R&D implies reclassifying the current expenditure to investment. This results in no additional impact on GDP but rather a re-allocation of expenditure.

77. The second step is then to calculate consumption of fixed capital (CFC) or depreciation using the FCF. CFC for R&D capital needs to be calculated and included in the accounts. The result is that government and non-profit expenditure increase by the estimate of CFC resulting in a similar increase to GDP.

78. The third step is to move the valuation to market prices. This requires the addition of taxes on products and the subtraction of subsidies on products. However, since these taxes and subsidies are already accounted for in the CSNA, there is no additional impact on GDP.

Quarterly data

79. Quarterly estimates of R&D components are required for full integration in the CSNA. The FM data published by Statistics Canada include intentions on R&D expenditure up to the year 2007. As a result, timely data are available for the estimation of R&D capitalization. However, these data are only provided on an annual basis. To create sub-annual estimates, a quarterly indicator series, based on R&D employment was created. This series was derived from occupational data that had high R&D concentrations (e.g., scientist, engineers, and university professors). The list of occupations used is provided in Appendix 12. These data, gleaned from the Statistics Canada's Labour Force Survey (LFS), were initially examined on an annual basis to ensure that they provided a good indication of R&D output. Quarterly results can be found in Appendix 1.

Regional data

80. Integration into the CSNA also requires annual regional R&D data. The FM data provide a regional picture of R&D expenditure in Canada. Funder and performer data are available by province and territory. Industry breakdowns can also be calculated from the survey data. Thus the same methodology used to calculate national R&D estimates can also be used by province since complete regional Input-Output (IO) tables are also available. However, inter-provincial or inter-regional trade data for R&D are not available and no estimates were calculated for this study. Availability of this data could affect the level of R&D investment in a region. For example, if a region is a net importer of R&D, they would have more investment to capitalize. Regional results are presented in Appendix 2.

Inventory accumulation (allocation)

81. Most R&D projects take time to complete and therefore it could be argued that there is an accumulation of R&D inventories or work in progress during this period. Once the project has been completed, the inventories could be capitalized. Depreciation estimates would then be based on the productive capital stock.

82. The draft *Handbook on Deriving Capital Measures of Intellectual Property Products*,[24] recommends that own account R&D be capitalized as it occurs while R&D for sale could be recorded as work in progress.

83. Many non-R&D assets in the CSNA that are being built on own account, are immediately capitalized. For example, construction work in progress is allocated to fixed capital in the period it was built and not placed into inventory. R&D, by its nature, is an attempt to add to "the stock of knowledge". From this perspective, R&D should be capitalized as it is undertaken.

24. "Aspden, Charles, "Handbook on Deriving Capital Measures of Intellectual Property Product (Software and R&D components), Draft" OECD, 2007."

84. This study does not place work-in-progress in inventories but rather treats them as part of the investment flow in the period in which the expenditure occurs. This treatment is in step with the international recommendations for R&D in the SNA93 Rev1.

Depreciation of research and development satellite account expenditure

85. There are two cases in which assets need to be depreciated in the RDSA. One is for depreciable assets used to generate R&D, as part of the process of moving expenditure data to output. The depreciation of these assets is relatively straightforward since they involve tangible assets such as buildings and other equipment. The other is the depreciation of intangible R&D assets by an industry/sector as used in a production process.

86. R&D differs from physical capital (like machines and buildings) in that it does not wear out. Rather, it loses value due to obsolescence, or possibly as a result of the ending of patent protection or the leakage of information to competitors about a given product. In fact, an argument given against changing the treatment of R&D in the SNA was that its asset lives are not known. Little information is also available concerning the rate of depreciation (e.g., linear or geometric). However this is not that different from other produced assets in which accurate information of asset lives and rates of depreciation is not always available.

87. Much like other assets, various assumptions can be made about lives and whether the rate of depreciation is accelerating over time for R&D. Several methods have been used to determine the asset life of R&D. They include using patent lives common to an industry, using the asset lives associated with a given industry for other capital and using the asset lives in the research and development related industries (NAICS 5415 and 5417). A survey of R&D producers asking for the expected service life of R&D has also been employed.

88. It should be noted that the consumption of fixed capital (CFC) that occurs with the depreciation of R&D assets used in a production process, are a portion of total operating surplus. Therefore, when business capital is depreciated, the type of model used (e.g., linear or geometric) or the length of the asset lives chosen, does not affect total GDP. It only changes the composition between capital consumption and net operating surplus.

89. It is only in the cases of government and non-profit funded R&D that asset lives and the model used have an effect on GDP as well as saving. This is because for these sectors the amount of CFC attributable to R&D is added to both income and expenditure for these entities thereby increasing factor incomes, final expenditure and value added for this sector.

90. Government R&D (which includes university R&D) is characterized by basic research. Studies from the U.S. indicate that two-thirds of university research and a quarter of federal government R&D is basic research.[25] This research tends to have longer and more stable asset lives than that of the fast moving technology-based R&D like computer software.

91. As a result, the asset lives for government and non-profit R&D were fixed at ten years for the whole study period. Various scenarios for asset lives were done to analyze the effect of asset lives on GDP. These results are presented in the results section at the end of the paper. Asset lives for business investment were set equal to the rate used for other capital in the same industry. A linear Perpetual Inventory Model (PIM) was used for all estimates, consistent with the estimation procedure used for other government assets in the Canadian SNA.[26] The depreciation of business investment used the average asset lives of the industry in which the R&D was performed.

25. Siddiqi and Salem, *A Proposal for Treating Research and Development as Capital Expenditures in the Canadian SNA*, Statistics Canada, page 17.

26. The U.S. satellite account provided results for two asset life scenarios. The first scenario used a 15 percent geometric rate of depreciation, the second used a rate that varied between four and six years, getting shorter as the capital expenditure became more current. This was an attempt to model the rapid pace of recent technological change.

Deflation

92. The deflation of research and development output encounters many of the same challenges as the deflation of other non-market products. In Canada, approximately 70% of R&D is undertaken on own-account and therefore is not directly sold on the market. That which is sold on the market is very heterogeneous and therefore using these prices as proxies for own-account R&D may not be accurate. As there is no market price in the conventional sense associated with the service provided, the cost of the inputs are used to measure price change. This method is suggested in the FM for the deflation of expenditures.

93. Input costs are broken down into two main types in the FM data–labour and other. The "other" component encompass various goods and services that enter into the production function such as rent, heat, electricity, office supplies and even raw materials used up in the research process. Since the FM surveys do not provide this detailed input information, corresponding data could be taken from the R&D related industries North American Industrial Classification System (NAICS 5415 and 5417) in the Input-Output (IO) system. Corresponding price indexes could be used to measure the change in prices of these items over time. These price indexes should take into consideration any changes in quality of the commodity in question, in order to measure pure price change.

94. This is also true of the labour component, however the separation of price and quality can be difficult to achieve. In this case, real estimates of non-market services usually rests on the assumption of constant productivity, with the volume estimates reflecting solely the change in the level of employment (hours worked). However, it is generally accepted that labour, in aggregate, has become more productive over time but the rate at which it has done so is not known. An R&D producer may also be using its other inputs more efficiently over time.

95. The U.S. RDSA used four different methods to deflate R&D estimates. The first used input prices. Labour costs were available to deflate labour inputs and other costs were deflated using prices from the R&D industry (NAICS 5417). The second method used prices from the five industries with the highest productivity in manufacturing; the third used the highest productivity services industries, while the fourth used prices from industries that were the most R&D intensive. The choice of method had a relatively small impact on GDP (a difference of less than 3% of R&D GDP).

96. The Canadian RDSA used one composite price index to deflate the detailed industry R&D expenditures. This price index was a weighted average of various price indexes for commodities thought to be representative of R&D inputs. The latter include price indexes for non-residential rent, computer-related goods and services, office supplies and telephone and other communications, as well as the All-items Consumer Price Index for the portion related to labour remuneration.[27] The All-items Consumer Price Index was also used for operating surplus. The Canadian RDSA does not introduce productivity differentials through prices as was done in the U.S. account. Rather, the possible productivity gains are theoretically measured by the premiums found in the various scenarios for operating surplus.

Stock-flow measurement issues

97. As the result of the nature of R&D as an intangible asset, the measurement of stocks and flows in R&D, when traded is a difficult issue. In this study, it is assumed that all exports or other traded R&D are for sale only. That is, the seller does not keep any of the stock of this R&D after the sale. This is not a fully realistic assumption in the Canadian case since there are documented cases of exchanges in assets and not just services. For example, R&D assets, in the form of patents, have been traded abroad. Further investigation of this issue is required.

27. Average earnings from the *Survey of Employment Payroll and Hours* (SEPH) undertaken by Statistics Canada could be another possible deflator for the labour data.

Research and Development Satellite Account

98. The objective of the RDSA is to examine the effects of changing the expenditures of selected components of research and development from current spending[28] to capital formation in the Canadian System of National Accounts (CSNA) sequence of accounts – both from the industry account side and from the sector accounts dimension. The RDSA detail will meet the requirements of both CSNA architectures, and will make for a straightforward link to the SNA93 Rev1 sequence of accounts.

99. The RDSA has been suggested as a method to investigate the impact of this change as well as to explore various options with respect to R&D inclusion.[29] This satellite account approach has been put forward by the Canberra Group. This approach would allow for work on the major balancing entries in the macro-economic system so that in the next few years, consistent estimates for measures such as GDP and savings, as well as measures for gross fixed capital formation and stocks of fixed capital can be implemented across countries.

100. In the Canadian satellite account all R&D is included, such that the impact on GDP is calculated with and without, for example, software as part of the R&D total. The RDSA then allows for the accounting of the total impact of R&D in the national economy as well as the additional impact or the change to GDP by broadening the coverage of R&D beyond the current treatment.

Structure of the Canadian Research and Development Satellite Account

101. The aim of this satellite account is to build a framework for incorporating measures of R&D capital into the core accounts. With this in mind, the satellite account will follow the sequence of accounts as presented in the SNA and show the impact on the key macro-economics variables.

Impact on the System of National Accounts component accounts

Production account and industry detail

102. The change in treatment of R&D will have varying impacts in the SNA depending on whether transactions involve the business, government or non-profit sector. A new R&D commodity will be created (similar to the commodity created for software capitalization) to record R&D. R&D associated with software will remain in its current commodity. R&D expenditures on mining will be included with R&D. However, exploration expenditures will continue to be presented separately.

Business sector

103. In the business sector, if an establishment was a producer but not a user of R&D, there is no impact to its industry. The R&D will remain as a sale and not be capitalized within that industry. Producers of R&D will continue to have some knowledge capital (they may or may not derive income) that is not capitalized. This knowledge capital is not dealt with in the RDSA.

104. The situation changes for non-producing buyers of R&D. In this case, the R&D, which is currently being treated as the purchase of an intermediate input, will now be capitalized and recorded in the capital account. Total current expenses will drop by the amount of R&D purchased resulting in an increase in operating surplus. Output remains unchanged as the decrease in expense will be offset by the increase in operating surplus. The increased surplus will be used to make the investment in R&D, thereby leaving net lending unchanged.

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28. Satellite accounts are based on the principles of the National Accounts but are developed as an extension to the core National Accounts System. This allows for a comparison between the satellite account (or area of interest) and the entire economy as measured by the SNA. With the RDSA, the impact on the level and growth rate of value added or GDP can be examined. A satellite account is a useful tool when developing a new variable for the accounts because: (a) it allows for the analysis of the impact of that variable on the account without disturbing the core of the account, (b) various definitions of the area of study can be examined and (c) several methods of implementation can be tried.

29. See minutes of the National Accounts Advisory Committee, June 2005.

105. Own-account producers of R&D will see an increase in output by the amount of the R&D capitalized. Operating surplus will increase with depreciation of the R&D invested. Intermediate expenses will remain unchanged. In the case of the various rate of return scenarios, the extra income resulting from these premiums would also increase surplus. Any purchases of R&D by an R&D producer, whether from a domestic source or imported, are considered as capital. In this case, intermediate expenses will decrease while operating surplus increases by the equivalent amount, leaving output unchanged.

Other sectors

106. In the government and non-profit sectors, a purchaser (funder) of R&D will record a decrease in current expenses since the R&D is now capitalized. Since government and non-profit output is equal to total cost, including these intermediate expenses, output will decrease. However, some value will be added back since the CFC of the R&D capital will be included in the valuation of the output. Therefore output will decrease by the amount of R&D investment less the CFC for the R&D capital stock.

107. In the case of government and non-profit own-account R&D, intermediate expenses will remain the same in total. However the intermediate expenses for non-R&D output will go down, as in the case above, but these intermediate inputs will now be used to produce R&D output that is capitalized. Also, as the CFC from the new capital investment is included in the valuation of the government output, value added and output increase by the amount of CFC added.

Primary income - surplus

108. As a result of the change in treatment of R&D, income arising from production increases in the SNA. This occurs because R&D is no longer treated as an expense in the accounts. Since expenses decrease, surplus increases. This increase matches the gain in investment. In the CSNA, the increase in surplus is registered in both CFC and net operating surplus.

Final expenditure

109. Business and government investment in the SNA will increase due to the change in treatment of R&D. Government current expenditure is reduced by the amount of expenditure on R&D. This is partially offset by an increase in CFC on the depreciated R&D assets.

Accumulation account

110. As a result of the change in treatment of R&D, investment and saving will increase in the **capital account**. In the Canadian SNA, the increase will be registered in the machinery and equipment line of the accounts, similar to the impact of software capitalization.

111. There is no direct impact in the sector **financial accounts** of including R&D as capital assets. This is because the net addition to investment is equal to the addition to saving from the reduction of operating expenses. Thus, there is no impact on net lending/borrowing for the total economy. There are no subsequent changes to corresponding financial instruments and therefore no explicit entries in the financial account.

Balance sheet account

112. A broadening of the treatment of capital to include R&D assets has a direct impact on both national wealth and sector estimates of assets, liabilities and net worth. National wealth includes both produced and non-produced assets. R&D is a produced intangible asset, which adds to the productive capacity of the economy. The asset values are sensitive to both the service lives assumed and the depreciation method chosen.

113. At the same time, sector account estimates of produced assets are more correctly measured by the inclusion of R&D capital and, as a result, estimates of sector net worth are improved. For corporations, the market estimate of future stream of earnings would implicitly reflect knowledge capital. Therefore, this increased coverage of assets allows for a better reconciliation of the market value of corporate equities and the net asset value estimate of net worth.[30]

114. The impact of changes in asset positions with respect to purchases/sales of R&D assets is an area that requires further research.

Other changes in asset accounts

115. The difference between the opening and closing values of R&D assets would reflect, in addition to the investment and depreciation of these assets: changes in the cost of reproducing these assets (price fluctuations), in the *Revaluation account*; and; write-ups/downs of R&D capital in the *Other changes in the volume of assets account.*

Alternative estimates of research and development capital

116. One issue that will be examined in the RDSA is the impact of various rates of return for R&D output in the business sector. Four scenarios, using different assumptions for rates of return, are presented in this study along with their impact on R&D GDP.

117. Another dimension to the RDSA is a tabulation of both **total** R&D capitalization as well as the **additional** impact on the economy of capitalizing additional R&D expenditures. For **total capitalization**, adjustments made for spending on software, trade of R&D, the CFC involved in the process of producing R&D and government and non-profit capital are included. The **additional capitalization** measure, on the other hand, examines the change to the core accounts as a result of broadening in the treatment of R&D and therefore excludes the above adjustments.

118. In the future, this satellite account can also be broadened to include other intangible assets on the SNA. This could include a study on innovation and its role in the economy.

Results: research and development investment relatively small but growing

119. Results of the RDSA are presented in the general order of the sequence of accounts as organized in the SNA. The presentation of the results will begin by examining the affects of the change in treatment of R&D on the production account. This will be followed by analysis of the generation and use of income accounts, the capital and finance accounts and finally the balance sheet accounts. Tables providing a detailed time series of the accounts are available in the appendix. Final expenditures, as presented in the CSNA, will then be looked at followed by the impact on industries. Impacts on the total economy, including various scenarios for rates of return will follow.

120. The RDSA allows for the study of the impact of R&D spending on the economic accounts. One view is to look at its **total capitalization** in the economy including its impact on the stock of capital; the other is analyzing **additional capitalization**, as a result of the change in treatment of R&D, in the SNA. All estimates use the additional activity data, unless otherwise specified. Furthermore, estimates are based on a scenario with no rate of return on own-account R&D added to operating surplus and are presented in real (constant dollar or volume) terms unless otherwise specified.

121. The impact of changing the treatment of R&D in the SNA is not large but it has been growing over time. In Canada, the level of GDP increases by 1.6% in 2004, compared to 0.9% for 1976. This gradual increase has resulted in little impact to the growth rates for the total economy. Since R&D is continuing to increase in importance

30. This increased coverage of assets would, all other things being equal, reduce residual corporate net worth.

in the economy, the sooner the change in treatment is introduced into the accounts, the smaller its initial impact will be. The inclusion of R&D also provides a more accurate view of the productive assets in the economy while improving sectoral measures of net worth.

The production account

Current dollar estimates

122. The impact on output of changing the treatment of R&D is less than the impact on GDP. This occurs because **purchased R&D** was considered an intermediate input under the previous methodology. With the change in treatment, these expenses are capitalized, and therefore moved to fixed capital formation. On the other hand, **own-account R&D** increases both output and value added. Since these expenses continue to be incurred by the organization producing the R&D, there is no impact on intermediate purchases. All the taxes and subsidies on production associated with R&D are already in the CSNA and therefore there is no change to the level of the taxes and subsidies (see Table 5).

Table 5 Current account—System of National Accounts – Total economy, additional impact, 2004

	millions of dollars
Production account	
Output	13,747
Business	11,745
Government and non-profit	2,002
Intermediate consumption	-6,644
Business	-2,296
Government and non-profit	-4,348
Taxes less subsidies on production	0
Gross domestic product	20,391
Business	14,041
Government and non-profit	6,350

123. As can be seen on Table 5, GDP increases by $20.4 billion in 2004. Operating surplus takes the full impact of the change in treatment of R&D to an asset, while labour income remains unchanged. Although labour income is involved in the production of R&D, this income has already been accounted for in the National Accounts (see Table 6). Over 85% of the increase to operating surplus is allocated to consumption of fixed capital or capital consumption allowance (CCA).

Table 6 Current account System of National Accounts—Total economy, additional impact, 2004

	millions of dollars
Generation of income	
Labour income	0
Operating surplus	20,391
Business	14,041
Government and non-profit	6,350
Consumption of fixed capital	17,399
Business	11,049
Government and non-profit	6,350
Net operating surplus	2,992
Business	2,992
Government and non-profit	0
Gross national income	20,391
Gross disposable income	20,391
Business	14,041
Government and non-profit	6,350

Use of income

124. With the reclassifying of R&D to an asset, investment expenditures increase. Assets generate additional income and operating surplus.

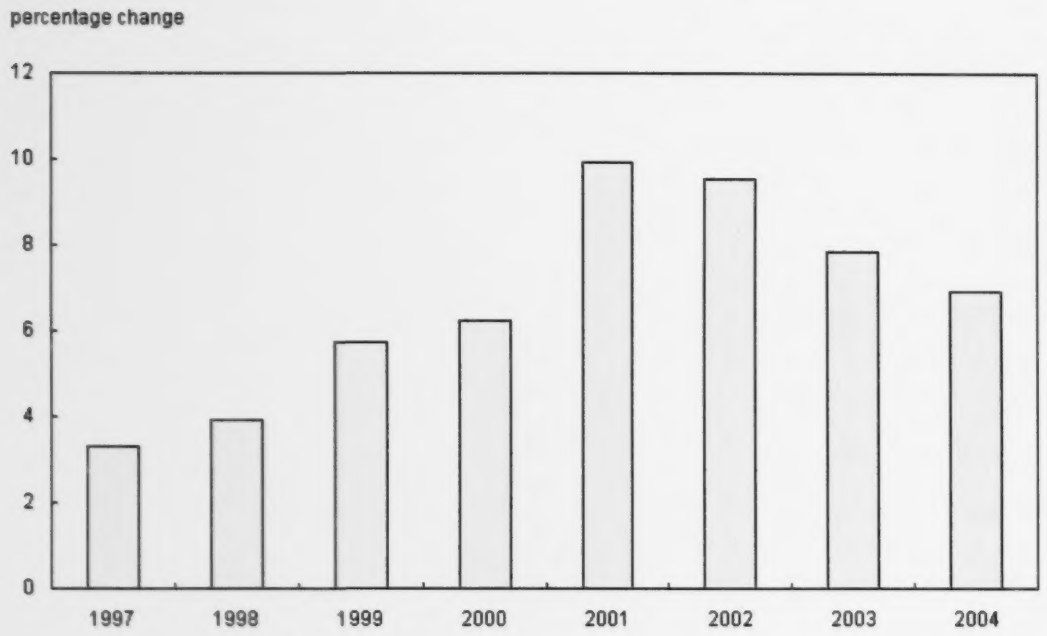
Table 7 Current account—System of National Accounts – Total economy, additional impact, 2004

	millions of dollars
Use of income	
Final consumption (outlays)	-3,833
Business	0
Government and non-profit	-3,833
Gross savings	24,224
Business	14,041
Government and non-profit	10,183
Net savings	6,825
Business	2,992
Government and non-profit	3,833

125. Economy-wide saving increases by $6.8 billion in 2004 (see Table 7). Corporate saving is increased by $3.0 billion. Government and non-profit organization activity shifts saving upward by $3.8 billion in 2004. Government saving is up $3.5 billion, with $1.3 billion accounted for at the federal government level and the remaining $2.2 billion for provincial governments.

126. The sector accounts for income and outlay reflect the fact that saving and capital consumption equal investment in the case of R&D. Capital acquisitions increase, as a result of the changing of R&D to assets, while income, through an increase in operating surplus, rises by the same amount. With the broadening of the definition of investment to include R&D, saving would increase 6.9% in 2004. This is down from a high of 9.9% in 2002 (see Graph 1).

Graph 1 Research and development increases savings



Accumulation accounts

Capital account

127. The main thrust of the change in the treatment of R&D is reflected in the capital account. The reclassification of R&D to FCF impacts GDP. In addition, this new investment drives corresponding changes to the capital stock in the balance sheet account.

Table 8 Capital and finance account—System of National Accounts – Total economy, additional impact, 2004

	millions of dollars
Capital account	
Gross savings	24,224
Business	14,041
Government and non-profit	10,183
Consumption of fixed capital	17,399
Business	11,049
Government and non-profit	6,350
Net savings	6,825
Business	2,992
Government and non-profit	3,833
Investment in fixed assets	24,224
Business	14,041
Government and non-profit	10,183
Financial account	
Net lending or borrowing	0
Business	0
Government and non-profit	0

128. The change in the treatment of capital would result in a $24.2 billion increase in fixed capital formation in 2004 (see Table 8). This represents an 8.5% increase from the current estimate. Of this, 58% or $14.0 billion is business capital formation.

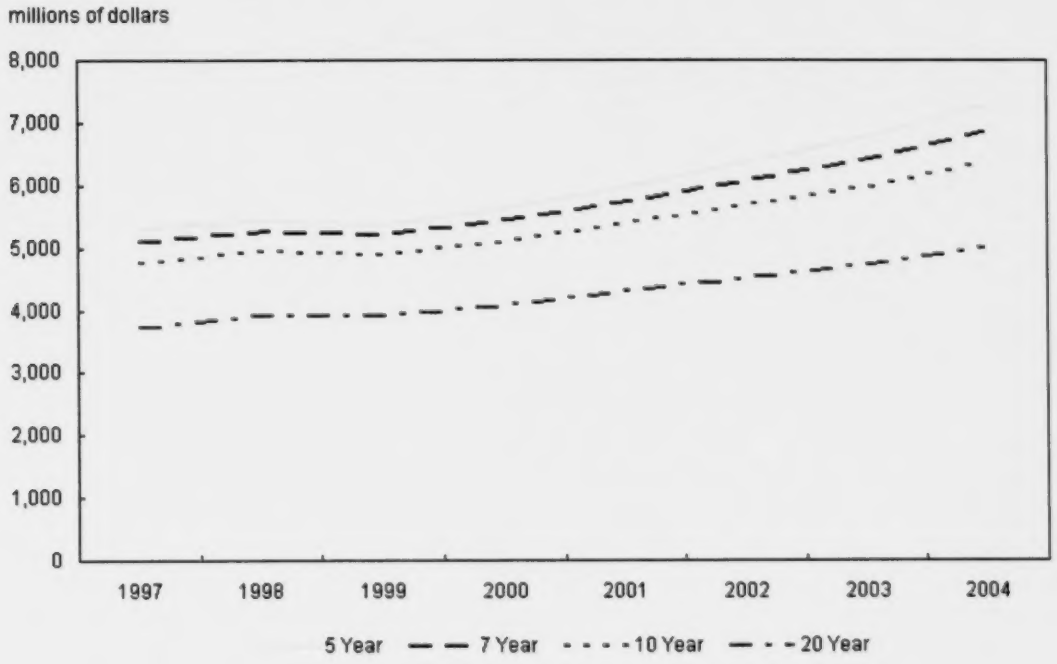
129. Net lending for the total economy remains unchanged since the increase in the capital account is offset by the increase in saving. All sectors register no change in net lending. On the other hand, gross saving increase by the same amount as gross investment. There is no impact on the financial account.

130. The nature of investment activities of the sectors involved in R&D differ. Business sector investment is much more likely to be applied research or experimental development than R&D in the government sector. Data is available on types of R&D for the business sector but not specifically for the government sector. Basic research comprises 4.5% of total expenditure for businesses in 2004. A U.S. study indicated that approximately two-thirds of university and one-quarter of government R&D spending was on basic research.[31]

131. Service life information for R&D investment is not directly available from the FM data however several scenarios of government CFC were calculated. Since government R&D is more focused on basic research, service lives may be fairly stable over time and were set at ten years as the base case for this study. Several other service life options were also calculated (five, seven and twenty years). The impact on government depreciation varied by up to $1.3 billion in 2004 from the base case as a result of these various options.

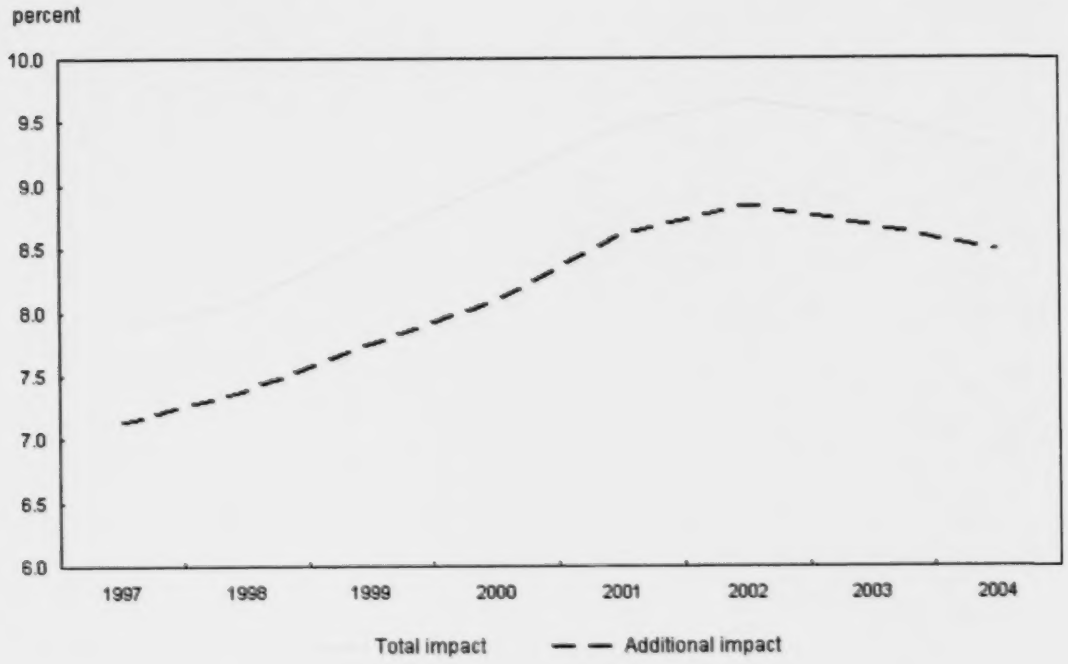
31. See "A Satellite Account for Research and Development" by Carol S. Carson in *Survey of Current Business*, November 1994, Volume 74, no. 11.

Graph 2 Consumption of fixed capital service life scenarios, government sector



132. The additional impact of R&D on investment varies from 7.1% to 8.8% over the 1997 to 2004 period in the base case scenario. This reflects the increase in investment for all sectors. The total investment includes the R&D components already treated as investment in the accounts. In 2004, this represented 9.3% of total investment. The difference between the additional and total impact widens slightly over time as software R&D becomes an increasingly important component in total R&D.

Graph 3 Research and development impact on investment



Balance sheet account

133. Since national saving increases, national wealth also increases by the amount of net investment/saving associated with R&D plus the revaluation of the capital stock of R&D. Nevertheless, the impact on sectoral and national wealth of R&D is relatively small in aggregate, though significant for certain industries.

Table 9 Balance sheet account—System of National Accounts – Total economy, additional impact, 2004

	millions of dollars
Opening balance sheet	
Net worth	144,640
Business	89,561
Government and non-profit	55,079
Changes in balance sheet (accumulation accounts)	
Transactions	
Net investment	6,825
Business	2,992
Government and non-profit	3,833
Revaluation	4,670
Business	4,533
Government and non-profit	137
Closing balance sheet	
Net worth	156,135
Business	97,086
Government and non-profit	59,049

134. R&D assets amounted to $156 billion dollars by year-end 2004, with business assets accounting for just over 60% of the total (see Table 10). The stock of R&D assets accounted for 0.1% of the total wealth in the Canadian economy. However, non-structures produced capital, increase by over 30% with the addition of R&D assets into the accounts.[32]

Table 10 Stock values for research and development

	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Total assets	**93,570**	**98,933**	**105,409**	**114,997**	**124,277**	**133,765**	**144,640**	**156,135**
Business	55,924	58,944	63,167	70,316	76,459	82,434	89,561	97,086
Government	35,122	37,056	38,755	40,626	43,304	46,395	49,778	53,315
Non-profit	2,524	2,933	3,487	4,055	4,514	4,936	5,301	5,734

135. Total R&D stock values increase by $11.5 billion in 2004 with the inclusion of R&D as an asset. Net investment (Total investment minus capital consumption allowances) accounts for 59% of this increase (see Table 11). Revaluation, which generally occurs due to price changes, contributed 41% of the total. Net investment contributed just over 68% of the total change in stock values in 2001, when R&D investment was booming.

32. R&D is included in machinery and equipment for presentational purposes in the CSNA. This results in a mix of intangible R&D assets and tangible machinery and equipment assets.

Table 11 Change in stock values

	1997	1998	1999	2000	2001	2002	2003	2004
Change in stock value								
Millions of dollars	5,225	5,363	6,476	9,588	9,280	9,488	10,875	11,495
Net investment								
Millions of dollars	2,183	2,465	4,046	5,087	6,352	6,261	6,355	6,825
Percent of total	41.8	46.0	62.5	53.1	68.4	66.0	58.4	59.4
Revaluation								
Millions of dollars	3,042	2,898	2,430	4,501	2,928	3,227	4,520	4,670
Percent of total	58.2	54.0	37.5	46.9	31.6	34.0	41.6	40.6

Nominal gross domestic product - Final expenditure

136. Government current expenditure decreases as a result of the change in treatment of R&D since these expenditures now move to capital investment, a final expenditure. Non-profit expenses, which are located in personal expenditure in the CSNA, decrease for the same reason. These expenditures are now capitalized.

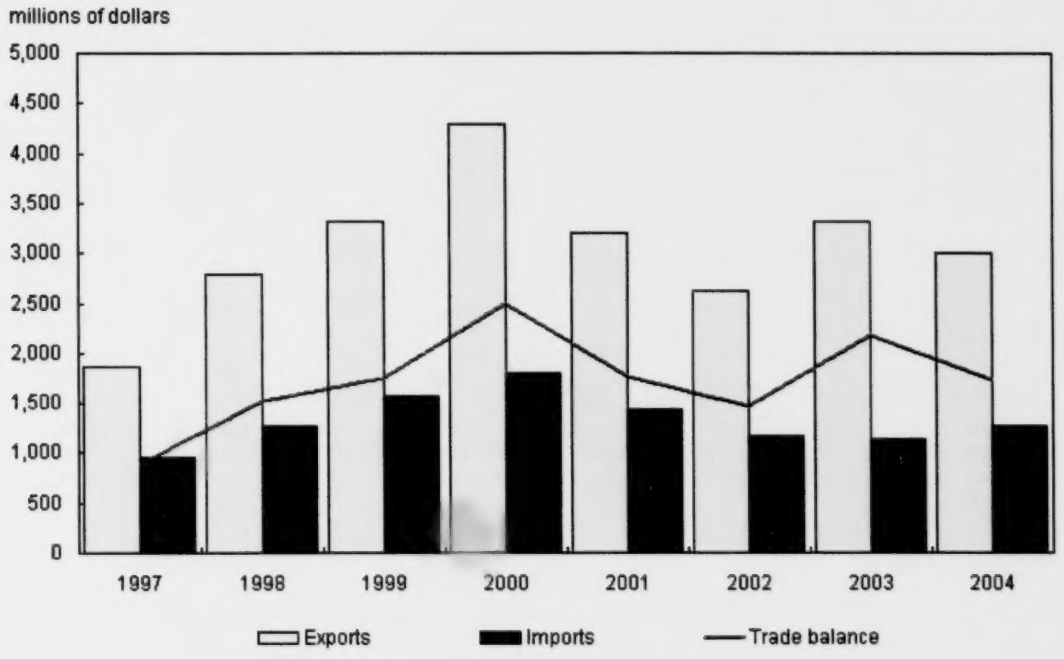
Table 12 Final expenditures, 2004

	Currently published	Additional research and development	Difference	% of final expenditure
	millions of dollars			
Personal expenditure	719,869	719,535	-334	0.0
Government expenditure	249,779	246,280	-3,499	-1.4
of which: current expenditure	226,194	216,345	-9,849	-4.6
of which: capital consumption allowance	23,585	29,935	6,350	21.2
Fixed capital formation	261,340	285,564	24,224	8.5
of which: business	229,787	243,828	14,041	5.8
of which: government	31,553	41,736	10,183	24.4
Inventories	6,185	6,185	0	0.0
Exports	494,578	494,578	0	0.0
Less imports	440,963	440,963	0	0.0
Gross domestic product at market prices	1,290,788	1,311,179	20,391	1.6

Trade data

137. Data from this study permit the analysis of R&D trade between Canada and other countries. Throughout the time period studied (1997 to 2004), Canada consistently was a net exporter of R&D. Exports of R&D peaked in 2000 at $4.3 billion. Imports ($1.8 billion) as well as the trade balance ($2.5 billion) also reached their highest level in that year. R&D exports represent 0.6% of total exports in 2000, much less than their contribution to GDP. The vast majority (88%) of industrial R&D is intramural, or done within an organization.

Graph 4 Canada, a net exporter of research and development



Industry analysis

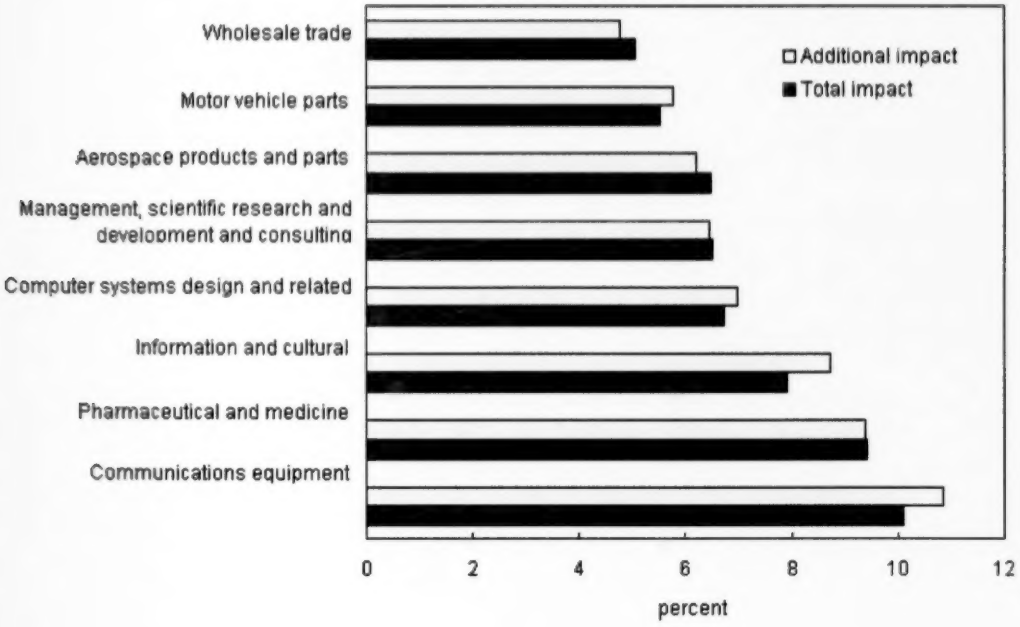
138. The following industry analysis is based on the total activity of R&D in the economy. In 2004, the industry that provided the largest activity as measured by fixed capital formation was communications equipment at $1.6 billion. The pharmaceutical manufacturing information and cultural service industries followed. The communications equipment industry provided the largest contribution to investment in all years but has been in sharp decline since 2001 (see Table 13). Industry data are available for both the total and additional impact on investment scenarios (see appendices 8 and 9).

Table 13 Industry share of total research and development investment

Industries	1997	1998	1999	2000	2001	2002	2003	2004
	percentage							
Communications equipment	15.6	14.9	19.9	18.0	19.8	14.2	12.0	10.1
Pharmaceutical and medicine	7.5	7.5	7.2	7.6	6.1	8.7	9.5	9.4
Information and cultural industries	3.0	2.8	2.5	2.3	4.1	4.2	6.5	7.9
Computer systems design and related services	5.3	5.9	6.0	6.0	7.1	7.1	6.8	6.7
Management, scientific research and development and consulting services	3.0	3.0	2.8	3.8	5.0	5.9	6.4	6.5
Aerospace products and parts	11.2	11.4	10.7	8.0	6.8	6.8	6.6	6.5
Motor vehicle parts	4.9	4.3	4.9	5.7	5.4	5.3	4.9	5.5
Wholesale trade	7.4	7.2	6.7	6.9	4.9	4.8	4.7	5.1

139. The **total** impact on an industry tends to be greater than the **additional** impact. The total impact includes software R&D. The share of R&D capital formation does vary depending on whether the total or additional impact is used (see Graph 5). For example, the communications equipment industry's share of total impact is lower than its additional impact suggesting it is less software intensive than other industries.

Graph 5 Industry shares of research and development capital formation, 2004



Aggregate economic activity

140. Table 14 provides summary statistics including the data for both types of impacts. In all cases, only direct measures of GDP are measured, indirect measures are not included on the impact of GDP. The numbers reflect the base case scenario of no return on own account R&D.

Table 14 Research and development summary, 1997 to 2004

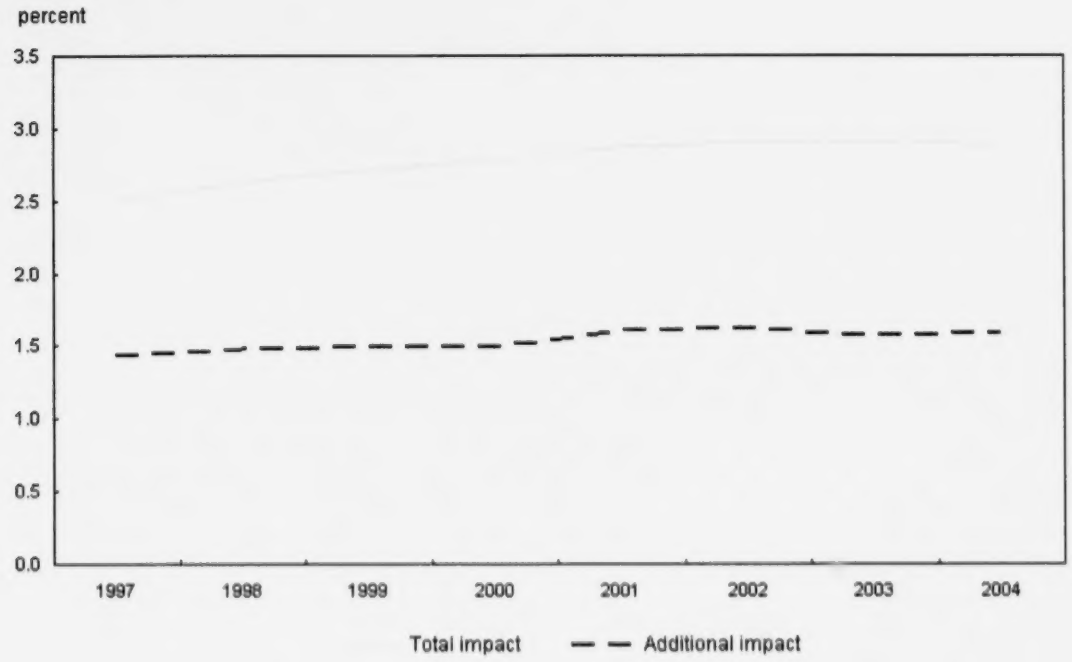
	1997	1998	1999	2000	2001	2002	2003	2004
Gross domestic product at market prices - additional research and development								
Millions of dollars	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391
Percentage change		7.0	7.9	9.9	10.5	4.8	2.6	6.7
Share of gross domestic product (percentage)	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.6
Gross domestic product at market prices- additional research and development								
Millions of chained (2002) dollars	12,690	13,335	14,311	15,642	16,782	17,279	17,287	17,885
Percentage change		5.1	7.3	9.3	7.3	3.0	0.0	3.5
Share of gross domestic product (percentage)	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.6
Real gross domestic product at market prices - total research and development								
Millions of dollars	20,463	22,329	24,717	27,836	29,659	31,043	32,995	34,628
Percentage change		9.1	10.7	12.6	6.6	4.7	6.3	4.9
Share of gross domestic product (percentage)	2.5	2.6	2.7	2.8	2.9	2.9	2.9	2.9
Research and development investment - additional research and development								
Millions of dollars	13,419	14,480	16,328	18,148	20,458	21,854	22,594	24,224
Percentage change		7.9	12.8	11.1	12.7	6.8	3.4	7.2
Share of investment	7.1	7.4	7.7	8.1	8.6	8.8	8.7	8.5
Research and development investment - total research and development								
Millions of dollars	14,821	15,878	18,070	20,245	22,511	23,902	24,844	26,549
Percentage change		7.1	13.8	12.0	11.2	6.2	3.9	6.9
Share of investment	7.9	8.1	8.6	9.0	9.5	9.7	9.5	9.3
Gross expenditure on research and development (GERD)								
Millions of dollars	14,634	16,088	17,637	20,580	23,169	23,539	24,337	26,003
Percentage change		9.9	9.6	16.7	12.6	1.6	3.4	6.8

141. In 2004, nominal GDP would increase by $20.4 billion or 1.6% if R&D expenditures were capitalized in the National Accounts. The impact has generally been increasing over time. GDP would increase 1.4% in 1997 and 0.9% in 1976[33] with the change in treatment. The greatest impact occurs in 2001. This corresponds with the height of the technology boom that took place in Canada, specifically in the telecommunication industry. From 1997

33. A backward projection was calculated for R&D capital at the total level using total FM based R&D expenditure data.

to 2004, additional R&D GDP grew 61% in nominal terms; higher than the 46% increase registered by the total economy. Since R&D GDP is growing more quickly than the rest of GDP, the growth rates of economy-wide GDP would increase over time, although the impact at the total level of GDP in a given year is less than 0.1%.

Graph 6 Research and development impact on Gross Domestic Product



142. When viewed from the total activity basis, the impact of R&D on the trend in the economy changes. The total activity in 2004 was $34.6 billion, 2.9% of the total economy. This value is higher than the total for the FM data (see GERD estimate in Table 14), largely as a result of the inclusion of government and non-profit CFC and due to adjustments made to international trade data.

143. Although the main focus of this study covers the years 1997 to 2004, historical estimates were calculated back to 1976. This study indicates that R&D has become increasingly important to the Canadian economy. In 1976, total R&D represented 1.5% of GDP, considerably less than the 2.9% share in 2004. This corresponds with the idea that intangible assets have become an ever more important part of a developed economy and therefore require measurement and inclusion in the core accounts.

144. An estimate was also made for the impact of capitalizing R&D on inflation-adjusted GDP. As is the case on the nominal side, GDP would rise by 1.6% in 2004.

Operating surplus and income accounts

145. In terms of the Income Accounts (including the Generation of Income and Primary Income Accounts in the SNA) changes are driven by the impact on operating surplus. Sensitivity analysis was carried out to find the impact of various rates of return scenarios on GDP. The scenarios included estimates where a rate of return was

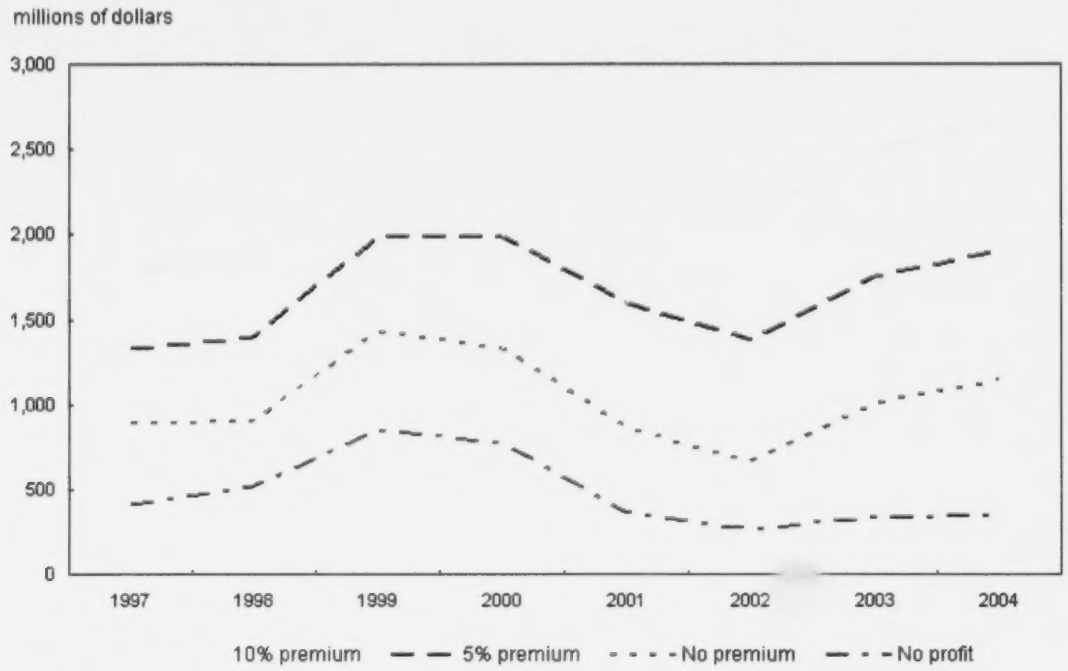
added only to R&D sold outside a firm (this study's base case), another where a return was included for all R&D (no premium case), and two other cases in which a five percent and a 10% premium were added to all returns for all R&D (see Table 15). These scenarios resulted in an impact of R&D capital on GDP ranging by $2.3 billion or 0.2% of the economy-wide GDP in 2004 (see appendices 10 and 11 for more details). The addition of a possible rate of return would affect total surplus in that a portion would be reallocated to be attributable to R&D.

Table 15 Gross domestic product and business net operating surplus – four scenarios, 1997 to 2004

Year	No premium		5% premium		10% premium		No profit (base case)	
	Gross domestic product at market prices	Business net operating surplus	Gross domestic product at market prices	Business net operating surplus	Gross domestic product at market prices	Business net operating surplus	Gross domestic product at market prices	Business net operating surplus
	millions of dollars							
1997	13,167	889	13,607	1,329	14,047	1,769	12,690	412
1998	13,954	897	14,450	1,393	14,946	1,889	13,578	521
1999	15,234	1,432	15,784	1,982	16,335	2,533	14,651	849
2000	16,658	1,330	17,314	1,986	17,969	2,641	16,099	771
2001	18,286	862	19,014	1,590	19,742	2,318	17,784	360
2002	19,036	666	19,747	1,377	20,459	2,089	18,630	260
2003	19,786	1,005	20,534	1,753	21,283	2,502	19,118	337
2004	21,198	1,147	21,959	1,908	22,720	2,669	20,391	340

146. It is interesting to note that the assumptions surrounding the rate of return have the biggest impact of any of the measurement issues concerning R&D and yet in these scenarios, the range of impact is very small relative to the economy-wide GDP measure.

Graph 7 Operating surplus scenarios



Comparisons to other studies

147. The results from this study suggest a marginally higher impact on GDP than the previous study undertaken by Statistics Canada.[34] The earlier study, produced for the year 2000, indicated an increase of 1.2% in GDP as a result of changing the treatment of R&D. The current study estimates an increase of 1.5% in 2000. The major differences between these two studies involve the treatment of operating surplus, which increased GDP by over $200 million in the base case scenario[35], a change in the treatment of software R&D, which added nearly $1 billion to GDP and different assumptions for government service lives.

148. Comparisons can also be made to a recently released U.S. study on the capitalization of R&D. Some adjustments are required to allow for a more accurate comparison. Software expenditures need to be added back to the Canadian additional total, as well as a reversal of the adjustments for trade. If this is done, the increase in GDP in 2002 would be $20.4 billion, or 1.8%, slightly less than the 2.3% to 2.6% range measured for the U.S. in the same year. Other countries have obtained similar results from their initial findings.[36]

34. Siddiqi and Salem, *A Proposal for Treating Research and Development as Capital Expenditures in the Canadian SNA*, Statistics Canada, June 2006.

35. This method is similar to the one used in the first Statistics Canada study but differs in that the rates of return used are specific to each industry rather than the rate of return for the R&D industry (NAICS 5[illegible]7).

36. This includes the Netherlands, Israel and several other OECD countries.

149. The higher U.S. share of GDP is attributed entirely to higher business sector investment on R&D, particularly in pharmaceutical and medicine manufacturing as well as the software publishing industry. Government spending on R&D has a larger share of the total spending in Canada versus the U.S.

Summary and future work

150. This study finds that R&D has a significant impact on the economy in terms of the level of GDP, although it has little impact on the growth rate. Reliable data are available from within Statistics Canada to produce these estimates. The proposed methodologies follow the emerging international guidelines although there are still some issues to be resolved in particular with the calculation of operating surplus and the asset boundaries of R&D.

151. There are five main outstanding issues that need to be resolved before implementing the expanded treatment of R&D within the SNA. The first involves the issue of the definition of R&D. Although the FM definition has been adopted, exclusions from this definition of R&D that do not provide economic benefits are not clearly defined and measurement issues exist. Secondly, the issue of the valuation of R&D also remains. In particular, the consideration of the addition of a rate of return for own-account R&D. Thirdly, estimating obsolescence via depreciation of R&D is also challenging as there is no information available on service lives of the R&D assets. A possible solution to this data gap is to survey R&D producers on their expectations of the service lives of their R&D. A fourth issue is that of trade, particularly across boundaries, and the possible impact this has on level of stocks of R&D capital. Movement within multi-national enterprises across borders is a particular concern. Lastly, since much R&D is done on own-account, prices are difficult to obtain. Input prices can be used as alternatives but these do not include any adjustment for productivity improvements.

152. An international agreement to adopt and further study the notion of R&D as an asset through satellite accounts has been accepted. As countries work towards implementing the change of treatment into their accounts, it will be important to investigate the similarities and differences amongst the various approaches taken. Based on the findings of other countries and the discussions within Canada, further work may be required before implementation into the core accounts.

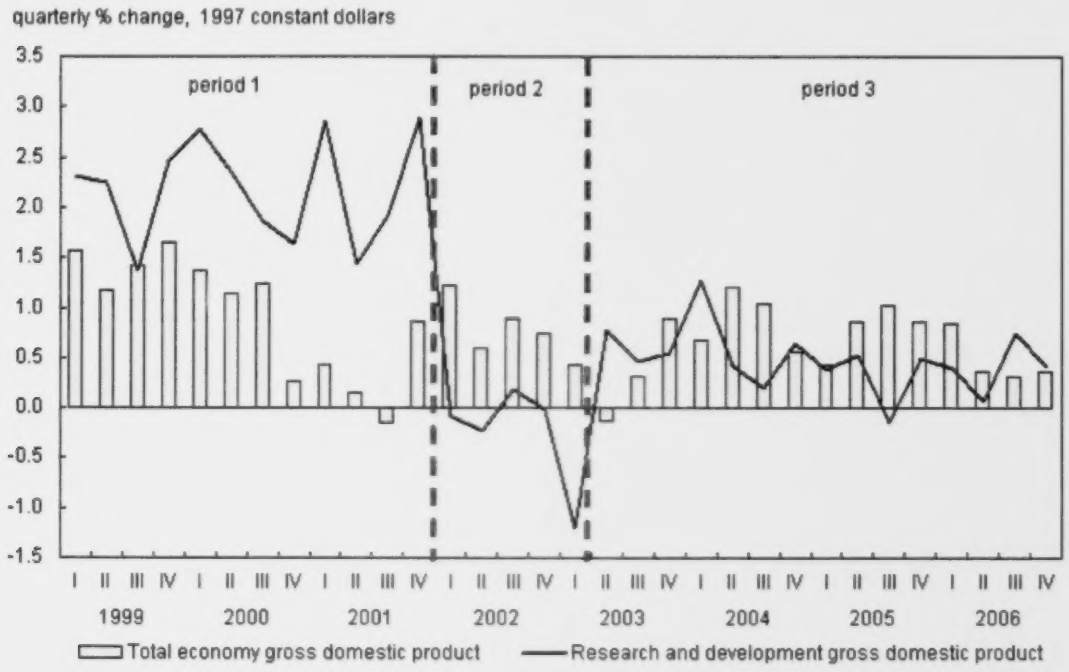
153. Despite the difficulties of measuring R&D, it is interesting to note that the results from most countries that have produced a satellite account are very similar with respect to the impact of the inclusion of R&D on GDP. Also, the impact on growth rates at the total economy level is negligible for most years. As we move into the future, these intangible capital assets will continue to increase in economic importance. The inclusion of R&D in a satellite account is a good first step towards incorporation of these economic phenomena in the core accounts.

Appendix 1 Real gross domestic product - Final expenditure on production

Quarterly estimates

1. Quarterly expenditure-based estimates of real R&D GDP were calculated from the annual series (see Appendix 7). These estimates were calculated for the years 1997 to 2006 and are required if the R&D estimates are to be integrated into the quarterly Income And Expenditure Accounts in the CSNA. In the years from 1997 to 2001, R&D GDP generally grew more quickly than the total economy (see graph A1). This trend reversed for the period from 2002 to the first quarter of 2003 as R&D was hit hard by the downturn in technology spending. In the last few years, growth rates for R&D GDP and GDP for the total economy have been similar.

Graph A1 Research and development gross domestic product experiences three differing periods of growth



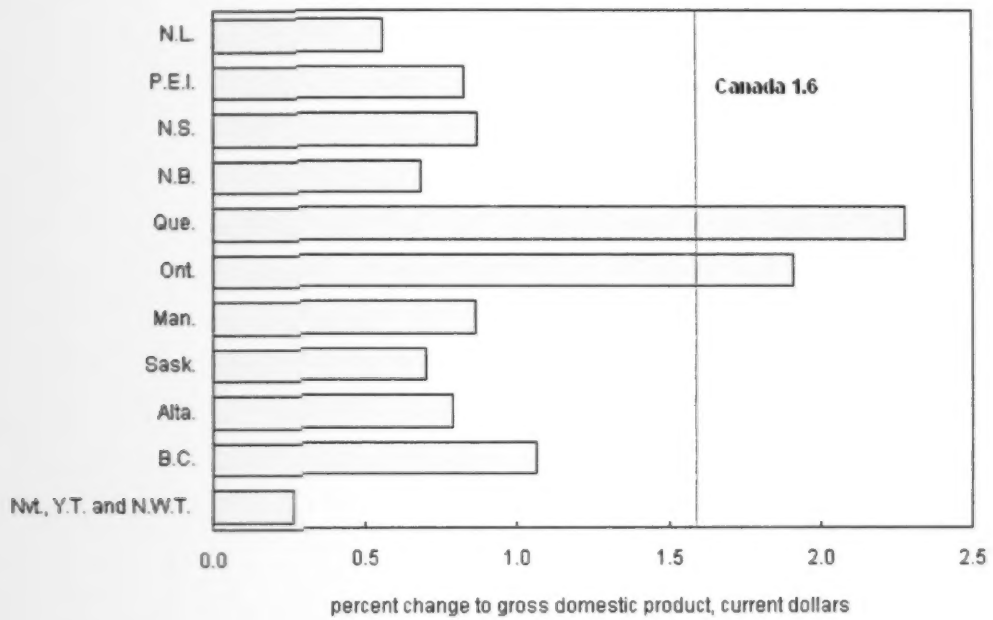
Appendix 2 Other accounts

Regional estimates

1. A further requirement for integrating the R&D estimates into the CSNA are regional estimates. The regional impact of R&D can be seen in Graph A2. Even though data are available for each province and territory, the territorial data are grouped for confidentiality reasons.

2. Quebec, followed by Ontario, has the highest concentration of R&D activity in Canada. The impact of the change in treatment of R&D exceeds the national average for both of these two provinces. These two provinces have large manufacturing industries, which are significant producers of R&D investment. The Quebec government also provides a high level of funding for R&D.

Graph A2 Regional impact of research and development on gross domestic product



Appendix 3

Table A.3 Reconciliation between Frascati Manual data and Research and Development Satellite Account

	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Frascati Manual survey data	14,634	16,088	17,637	20,580	23,169	23,539	24,337	26,003
Coverage								
Capital expenditure	-1,306	-1,431	-1,575	-1,800	-2,126	-1,714	-1,602	-1,600
Subsidies on production	-113	-92	-93	-87	-98	-92	-117	-107
Software	-478	-511	-570	-821	-783	-875	-940	-993
Valuation								
Net operating surplus	412	521	849	771	360	260	337	340
Capital consumption	962	1,026	1,064	1,117	1,235	1,320	1,327	1,346
Taxes on production	140	155	157	167	178	176	175	184
International trade								
Export adjustment	63	243	613	708	291	708	1,262	780
Total research and development produced in Canada	14,314	15,999	18,082	20,635	22,226	23,322	24,779	25,953
Exports of research and development	-1,857	-2,795	-3,319	-4,288	-3,210	-2,632	-3,325	-2,999
Imports of research and development	962	1,276	1,565	1,801	1,442	1,164	1,140	1,270
Additional research and development capital investment	**13,419**	**14,480**	**16,328**	**18,148**	**20,458**	**21,854**	**22,594**	**24,224**

Appendix 4

Table A.4 Current account—System of National Accounts

	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Production account								
Output	9,249	9,809	10,121	10,956	12,192	12,983	12,931	13,747
Business	6,343	6,709	7,445	8,372	10,065	10,863	11,070	11,745
Government and non-profit	2,906	3,100	2,676	2,584	2,127	2,120	1,861	2,002
Intermediate consumption	-3,441	-3,769	-4,530	-5,143	-5,592	-5,647	-6,188	-6,644
Business	-1,600	-1,936	-2,312	-2,624	-2,339	-2,094	-2,082	-2,296
Government and non-profit	-1,841	-1,833	-2,218	-2,519	-3,253	-3,553	-4,106	-4,348
Taxes less subsidies on production	0	0	0	0	0	0	0	0
Gross domestic product	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391
Business	7,943	8,645	9,758	10,996	12,404	12,957	13,151	14,041
Government and non-profit	4,747	4,933	4,893	5,103	5,380	5,673	5,967	6,350
Generation of income								
Labour income	0	0	0	0	0	0	0	0
Operating surplus	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391
Business	7,943	8,645	9,758	10,996	12,404	12,957	13,151	14,041
Government and non-profit	4,747	4,933	4,893	5,103	5,380	5,673	5,967	6,350
Consumption of fixed capital	11,236	12,015	12,282	13,061	14,106	15,593	16,239	17,399
Business	6,489	7,082	7,389	7,958	8,726	9,920	10,272	11,049
Government and non-profit	4,747	4,933	4,893	5,103	5,380	5,673	5,967	6,350
Net operating surplus	1,454	1,563	2,369	3,038	3,678	3,037	2,879	2,992
Business	1,454	1,563	2,369	3,038	3,678	3,037	2,879	2,992
Government and non-profit	0	0	0	0	0	0	0	0
National income	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391
Disposable income	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391
Business	7,943	8,645	9,758	10,996	12,404	12,957	13,151	14,041
Government and non-profit	4,747	4,933	4,893	5,103	5,380	5,673	5,967	6,350
Use of income								
Final consumption (outlays)	-729	-902	-1,677	-2,049	-2,674	-3,224	-3,476	-3,833
Business	0	0	0	0	0	0	0	0
Government and non-profit	-729	-902	-1,677	-2,049	-2,674	-3,224	-3,476	-3,833
Gross savings	13,419	14,480	16,328	18,148	20,458	21,854	22,594	24,224
Business	7,943	8,645	9,758	10,996	12,404	12,957	13,151	14,041
Government and non-profit	5,476	5,835	6,570	7,152	8,054	8,897	9,443	10,183
Net savings	2,183	2,465	4,046	5,087	6,352	6,261	6,355	6,825
Business	1,454	1,563	2,369	3,038	3,678	3,037	2,879	2,992
Government and non-profit	729	902	1,677	2,049	2,674	3,224	3,476	3,833

Appendix 5

Table A.5 Capital account—System of National Accounts

	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Capital account								
Gross savings	13,419	14,480	16,328	18,148	20,458	21,854	22,594	24,224
Business	7,943	8,645	9,758	10,996	12,404	12,957	13,151	14,041
Government and non-profit	5,476	5,835	6,570	7,152	8,054	8,897	9,443	10,183
Consumption of fixed capital	11,236	12,015	12,282	13,061	14,106	15,593	16,239	17,399
Business	6,489	7,082	7,389	7,958	8,726	9,920	10,272	11,049
Government and non-profit	4,747	4,933	4,893	5,103	5,380	5,673	5,967	6,350
Net savings	2,183	2,465	4,046	5,087	6,352	6,261	6,355	6,825
Business	1,454	1,563	2,369	3,038	3,678	3,037	2,879	2,992
Government and non-profit	729	902	1,677	2,049	2,674	3,224	3,476	3,833
Investment in fixed assets	13,419	14,480	16,328	18,148	20,458	21,854	22,594	24,224
Business	7,943	8,645	9,758	10,996	12,404	12,957	13,151	14,041
Government and non-profit	5,476	5,835	6,571	7,152	8,054	8,897	9,443	10,183
Financial account								
Net lending or borrowing	0	0	0	0	0	0	0	0
Business	0	0	0	0	0	0	0	0
Government and non-profit	0	0	0	0	0	0	0	0

Appendix 6

Table A.6 Balance sheet account Current account—System of National Accounts

	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Opening balance sheet								
Net worth	88,345	93,570	98,933	105,409	114,997	124,277	133,765	144,640
Business	52,458	55,924	58,944	63,167	70,316	76,459	82,434	89,561
Government and non-profit	35,887	37,646	39,989	42,242	44,681	47,818	51,331	55,079
Changes in balance sheet (accumulation accounts)								
Transactions								
Net investment	2,183	2,465	4,046	5,087	6,352	6,261	6,355	6,825
Business	1,454	1,563	2,369	3,038	3,678	3,037	2,879	2,992
Government and non-profit	729	902	1,677	2,049	2,674	3,224	3,476	3,833
Revaluation	3,042	2,898	2,430	4,501	2,928	3,227	4,520	4,670
Business	2,012	1,457	1,854	4,111	2,465	2,938	4,248	4,533
Government and non-profit	1,030	1,441	576	390	463	289	272	137
Closing balance sheet								
Net worth	93,570	98,933	105,409	114,997	124,277	133,765	144,640	156,135
Business	55,924	58,944	63,167	70,316	76,459	82,434	89,561	97,086
Government and non-profit	37,646	39,989	42,242	44,681	47,818	51,331	55,079	59,049

Appendix 7

Table A.7 Additional impact on gross domestic product

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	millions of dollars									
Expenditure										
Personal expenditure	-132	-118	-120	-177	-233	-297	-277	-334	-353	-363
Government expenditure	-597	-784	-1,557	-1,872	-2,441	-2,927	-3,199	-3,499	-4,268	-5,031
Current expenditure	-5,110	-5,463	-6,192	-6,707	-7,519	-8,272	-8,813	-9,461	-10,551	-11,658
Capital consumption allowance	4,513	4,679	4,635	4,835	5,078	5,345	5,614	5,962	6,283	6,627
Fixed capital formation	13,419	14,480	16,328	18,148	20,458	21,854	22,594	24,224	25,809	27,335
Fixed capital formation (business)	7,943	8,645	9,758	10,996	12,404	12,957	13,151	14,041	14,480	14,851
Fixed capital formation (government)	5,476	5,835	6,570	7,152	8,054	8,897	9,443	10,183	11,329	12,484
Inventories	0	0	0	0	0	0	0	0	0	0
Exports	0	0	0	0	0	0	0	0	0	0
Less imports	0	0	0	0	0	0	0	0	0	0
Gross domestic product at market prices	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391	21,188	21,941
Income										
Labour income	0	0	0	0	0	0	0	0	0	0
Net indirect taxes	0	0	0	0	0	0	0	0	0	0
Total operating surplus	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391	21,188	21,941
Capital consumption allowance	11,236	12,015	12,282	13,061	14,106	15,593	16,239	17,399	18,658	20,040
Net operating surplus	1,454	1,563	2,369	3,038	3,678	3,037	2,879	2,992	2,530	1,901
Gross domestic product at market prices	12,690	13,578	14,651	16,099	17,784	18,630	19,118	20,391	21,188	21,941

Appendix 8

Table A.8 Research and development business capital formation by industry—additional impact, 1997 to 2004

Industries	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Agriculture	35	33	43	51	65	86	64	67
Forestry and logging	17	13	22	20	13	15	15	14
Fishing, hunting and trapping	1	1	1	3	3	1	2	1
Total agriculture, forestry, fishing and hunting	**53**	**47**	**66**	**74**	**81**	**102**	**81**	**82**
Oil and gas extraction	104	110	103	157	188	209	232	288
Mining	105	115	117	120	127	153	161	183
Total mining and oil and gas extraction	**209**	**225**	**220**	**277**	**315**	**362**	**393**	**471**
Electric power	218	226	234	226	231	181	149	159
Other utilities	1	1	1	1	1	2	3	3
Total utilities	**219**	**227**	**235**	**227**	**232**	**183**	**152**	**162**
Construction	**32**	**38**	**47**	**60**	**60**	**59**	**52**	**53**
Food	87	77	81	89	88	108	132	147
Beverage and tobacco	18	16	23	22	25	30	44	28
Textile	34	45	50	64	70	75	80	87
Wood products	29	35	45	41	47	53	49	48
Paper	153	176	141	270	449	429	418	492
Printing	9	11	11	14	19	23	24	28
Petroleum and coal products	210	228	112	86	104	135	171	167
Pharmaceutical and medicine	634	704	745	893	778	1106	1235	1316
Other chemicals	162	174	166	198	186	221	222	195
Plastic products	70	69	70	79	89	100	120	128
Rubber products	53	54	62	73	70	73	76	78
Non-metallic mineral products	22	25	28	28	37	54	54	59
Primary metal (ferrous)	27	26	26	30	56	48	36	43
Primary metal (non-ferrous)	153	151	146	138	151	179	216	214
Fabricated metal products	66	80	94	110	141	180	195	194
Machinery	290	331	379	436	459	485	469	483
Computer and peripheral equipment	138	132	130	162	148	163	145	134
Communications equipment	1,227	1,322	1,997	2,063	2,543	1,994	1,749	1,523
Semi conductor and other electronic components	248	317	429	591	590	740	758	819
Navigational, measuring, medical and control instruments	260	271	278	353	323	235	229	243

Table A.8 Research and development business capital formation by industry—additional impact, 1997 to 2004

Industries	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Other computer and electronic equipment	18	16	15	12	9	14	9	18
Electrical equipment, appliance and components	35	37	38	49	52	51	40	38
Motor vehicle parts	423	386	503	643	707	723	691	809
Aerospace products and parts	857	971	1013	847	822	847	828	871
All other transportation equipment	15	27	24	36	33	21	27	44
Furniture and related products	7	7	15	16	22	32	34	34
Other manufacturing industries	81	82	84	92	113	117	110	118
Total manufacturing	**5,326**	**5,770**	**6,705**	**7,435**	**8,131**	**8,236**	**8,161**	**8,358**
Wholesale trade	552	578	620	718	580	587	579	670
Retail trade	28	26	27	27	40	40	33	24
Transportation and warehousing	33	40	42	51	48	61	44	49
Information and cultural industries	217	209	237	252	486	570	912	1227
Finance, insurance and real estate	172	167	157	140	262	325	277	378
Architectural, engineering and related services	240	302	291	290	313	319	285	311
Computer systems design and related services	440	538	588	727	944	960	943	981
Management, scientific research and development and consulting services	255	281	291	427	610	736	830	907
Health care and social assistance	112	148	177	223	227	326	283	269
All other services	55	49	55	69	75	91	127	99
Total services	**2,104**	**2,338**	**2,485**	**2,924**	**3,585**	**4,015**	**4,313**	**4,915**
Total all industries	**7,943**	**8,645**	**9,758**	**10,997**	**12,404**	**12,957**	**13,152**	**14,041**

Appendix 9

Table A.9 Research and development business capital formation by industry—total impact, 1997 to 2004

Industries	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Agriculture	35	34	43	55	71	93	68	71
Forestry and logging	18	14	24	21	14	16	17	15
Fishing, hunting and trapping	1	1	1	3	3	1	1	1
Total agriculture, forestry, fishing and hunting	**54**	**49**	**68**	**79**	**88**	**110**	**86**	**87**
Oil and gas extraction	114	114	113	185	219	232	250	310
Mining	112	123	125	131	134	166	176	202
Total mining and oil and gas extraction	**226**	**237**	**238**	**316**	**353**	**398**	**426**	**512**
Electric power	246	276	287	269	273	207	178	197
Other utilities	1	1	2	1	1	2	4	4
Total utilities	**247**	**277**	**289**	**270**	**274**	**209**	**182**	**201**
Construction	**32**	**37**	**47**	**63**	**64**	**63**	**55**	**57**
Food	95	84	88	97	97	119	145	162
Beverage and tobacco	23	20	30	29	32	38	60	37
Textile	38	51	58	74	80	85	91	99
Wood products	31	37	51	44	51	58	53	51
Paper	152	178	143	307	542	473	447	528
Printing	10	12	13	16	23	28	28	33
Petroleum and coal products	178	195	86	65	84	120	157	147
Pharmaceutical and medicine	675	730	792	946	857	1,252	1,409	1,475
Other chemicals	170	185	173	207	194	232	232	204
Plastic products	75	75	75	86	98	112	135	146
Rubber products	54	56	64	77	72	74	78	80
Non-metallic mineral products	23	25	30	30	41	60	59	66
Primary metal (ferrous)	27	27	27	33	58	49	35	42
Primary metal (non-ferrous)	158	158	153	147	165	200	238	216
Fabricated metal products	72	88	105	124	158	206	223	223
Machinery	330	375	437	509	533	546	527	544
Computer and peripheral equipment	135	132	135	175	143	159	145	133
Communications equipment	1,402	1,442	2,202	2,254	2,774	2,054	1,768	1,585
Semi conductor and other electronic components	260	321	432	636	532	666	727	787
Navigational, measuring, medical and control instruments	312	366	386	472	405	398	403	418
Other computer and electronic equipment	18	17	17	14	10	16	11	23

Table A.9 Research and development business capital formation by industry—total impact, 1997 to 2004

Industries	1997	1998	1999	2000	2001	2002	2003	2004
	millions of dollars							
Electrical equipment, appliance and components	40	42	42	55	57	58	44	41
Motor vehicle parts	444	415	540	710	762	764	726	864
Aerospace products and parts	1,009	1,106	1,185	1,005	957	982	972	1,018
All other transportation equipment	16	29	27	40	36	22	29	47
Furniture and related products	8	8	17	17	24	36	37	39
Other manufacturing industries	91	91	92	100	126	133	126	134
Total manufacturing	**5,846**	**6,265**	**7,400**	**8,269**	**8,911**	**8,940**	**8,905**	**9,142**
Wholesale trade	663	695	740	858	681	688	698	793
Retail trade	30	26	31	37	57	58	45	30
Transportation and warehousing	36	46	50	62	58	73	53	58
Information and cultural industries	267	273	274	285	580	600	965	1,241
Finance, insurance and real estate	304	279	243	247	361	440	423	546
Architectural, engineering and related services	349	436	456	487	546	538	517	535
Computer systems design and related services	472	568	661	750	991	1,020	1,008	1,057
Management, scientific research and development and consulting services	272	295	312	470	702	845	944	1,023
Health care and social assistance	115	152	180	227	228	334	293	280
All other services	73	59	65	81	98	123	156	126
Total services	**2,581**	**2,829**	**3,012**	**3,504**	**4,302**	**4,719**	**5,102**	**5,689**
Total all industries	**8,986**	**9,694**	**11,054**	**12,501**	**13,992**	**14,439**	**14,756**	**15,688**

Appendix 10

Table A.10-1 Research and development output, base case—no profits, 2004

Input/Output industry codes	Research and development current expenditures	Subsidies on products	Software	Taxes on production	Net operating surplus	Capital consumption	Total research and development output
	(1)	(2)	(3)	(4)	(5)	(6)	=(1-2-3+4+5+6)
	millions of dollars						
1A Crop and animal production	49	0	0	2	5	3	59
1B Forestry and logging	5	1	0	0	0	0	4
1C Fishing, hunting and trapping	1	0	0	0	0	0	1
1D Support activities for agriculture and forestry	30	3	0	1	2	2	32
21 Mining and oil and gas extraction	248	0	0	4	15	70	337
22 Utilities	123	0	0	9	13	20	165
23 Construction	53	1	2	3	0	3	56
3A Manufacturing	8,167	46	182	70	145	543	8,697
41 Wholesale trade	735	2	47	27	51	37	801
4A Retail trade	22	0	6	1	0	5	22
4B Transportation and warehousing	35	0	0	2	0	2	39
51 Information and cultural industries	1,232	3	39	3	16	57	1,266
5A Finance, insurance, real estate and renting and leasing	305	0	84	14	0	11	246
54 Professional, scientific and technical services	2,813	48	260	32	76	171	2,784
56 Administrative and support, waste management and remediation services	50	1	10	1	1	2	43
61 Education services	5	0	2	0	0	0	3
62 Health care and social assistance	372	1	1	14	15	25	424
71 Arts, entertainment and recreation	4	0	0	0	0	0	4
72 Accommodation and food services	8	0	0	0	0	0	8
81 Other services (except public administration)	37	1	3	1	1	3	38
Business sector	**14,294**	**107**	**636**	**184**	**340**	**954**	**15,029**
Non-profit institutions	109	0	4	0	0	3	108
Universities	8,535	0	280	0	0	242	8,497
Provincial government	314	0	10	0	0	8	312
Federal government	1,931	0	63	0	0	139	2,007
Government sector	**10,889**	**0**	**357**	**0**	**0**	**392**	**10,924**
Total business plus government	**25,183**	**107**	**993**	**184**	**340**	**1,346**	**25,953**

Appendix 10

Table A.10-2 Research and development output, profits—no premium, 2004

Input/Output industry codes	Research and development current expenditures	Subsidies on products	Software	Taxes on production	Net operating surplus	Capital consumption	Total research and development output
	(1)	(2)	(3)	(4)	(5)	(6)	=(1-2-3+4+5+6)
	millions of dollars						
1A Crop and animal production	49	0	0	2	8	3	62
1B Forestry and logging	5	1	0	0	0	0	4
1C Fishing, hunting and trapping	1	0	0	0	0	0	1
1D Support activities for agriculture and forestry	30	3	0	1	1	2	31
21 Mining and oil and gas extraction	248	0	0	4	59	70	381
22 Utilities	123	0	0	9	105	20	257
23 Construction	53	1	2	3	0	3	56
3A Manufacturing	8,167	46	182	70	384	543	8,936
41 Wholesale trade	735	2	47	27	97	37	847
4A Retail trade	22	0	6	1	-2	5	20
4B Transportation and warehousing	35	0	0	2	6	2	45
51 Information and cultural industries	1,232	3	39	3	290	57	1,540
5A Finance, insurance, real estate and renting and leasing	305	0	84	14	71	11	317
54 Professional, scientific and technical services	2,813	48	260	32	111	171	2,819
56 Administrative and support, waste management and remediation services	50	1	10	1	5	2	47
61 Education services	5	0	2	0	0	0	3
62 Health care and social assistance	372	1	1	14	7	25	416
71 Arts, entertainment and recreation	4	0	0	0	0	0	4
72 Accommodation and food services	8	0	0	0	2	0	10
81 Other services (except public administration)	37	1	3	1	3	3	40
Business sector	**14,294**	**107**	**636**	**184**	**1,147**	**954**	**15,836**
Non-profit institutions	109	0	4	0	0	3	108
Universities	8,535	0	280	0	0	242	8,497
Provincial government	314	0	10	0	0	8	312
Federal government	1,931	0	63	0	0	139	2,007
Government sector	**10,889**	**0**	**357**	**0**	**0**	**392**	**10,924**
Total business plus government	**25,183**	**107**	**993**	**184**	**1,147**	**1,346**	**26,760**

Appendix 10

Table A.10-3 Research and development output, profits—5% premium, 2004

Input/Output industry codes	Research and development current expenditures	Subsidies on products	Software	Taxes on production	Net operating surplus	Capital consumption	Total research and development output
	(1)	(2)	(3)	(4)	(5)	(6)	=(1-2-3+4+5+6)
	millions of dollars						
1A Crop and animal production	49	0	0	2	11	3	65
1B Forestry and logging	5	1	0	0	1	0	5
1C Fishing, hunting and trapping	1	0	0	0	0	0	1
1D Support activities for agriculture and forestry	30	3	0	1	2	2	32
21 Mining and oil and gas extraction	248	0	0	4	73	70	395
22 Utilities	123	0	0	9	117	20	269
23 Construction	53	1	2	3	3	3	59
3A Manufacturing	8,167	46	182	70	811	543	9,363
41 Wholesale trade	735	2	47	27	136	37	886
4A Retail trade	22	0	6	1	-1	5	21
4B Transportation and warehousing	35	0	0	2	8	2	47
51 Information and cultural industries	1,232	3	39	3	358	57	1,608
5A Finance, insurance, real estate and renting and leasing	305	0	84	14	86	11	332
54 Professional, scientific and technical services	2,813	48	260	32	261	171	2,969
56 Administrative and support, waste management and remediation services	50	1	10	1	8	2	50
61 Education services	5	0	2	0	0	0	3
62 Health care and social assistance	372	1	1	14	27	25	436
71 Arts, entertainment and recreation	4	0	0	0	0	0	4
72 Accommodation and food services	8	0	0	0	2	0	10
81 Other services (except public administration)	37	1	3	1	5	3	42
Business sector	**14,294**	**107**	**636**	**184**	**1,908**	**954**	**16,597**
Non-profit institutions	109	0	4	0	0	3	108
Universities	8,535	0	280	0	0	242	8,497
Provincial government	314	0	10	0	0	8	312
Federal government	1,931	0	63	0	0	139	2,007
Government sector	**10,889**	**0**	**357**	**0**	**0**	**392**	**10,924**
Total business plus government	**25,183**	**107**	**993**	**184**	**1,908**	**1,346**	**28,521**

Appendix 10

Table A.10-4 Research and development output, profits—10% premium, 2004

Input/Output industry codes	Research and development current expenditures	Subsidies on products	Software	Taxes on production	Net operating surplus	Capital consumption	Total research and development output
	(1)	(2)	(3)	(4)	(5)	(6)	=(1-2-3+4+5+6)
	millions of dollars						
1A Crop and animal production	49	0	0	2	13	3	67
1B Forestry and logging	5	1	0	0	1	0	5
1C Fishing, hunting and trapping	1	0	0	0	0	0	1
1D Support activities for agriculture and forestry	30	3	0	1	4	2	34
21 Mining and oil and gas extraction	248	0	0	4	87	70	409
22 Utilities	123	0	0	9	129	20	281
23 Construction	53	1	2	3	5	3	61
3A Manufacturing	8,167	46	182	70	1,238	543	9,790
41 Wholesale trade	735	2	47	27	175	37	925
4A Retail trade	22	0	6	1	0	5	22
4B Transportation and warehousing	35	0	0	2	10	2	49
51 Information and cultural industries	1,232	3	39	3	426	57	1,676
5A Finance, insurance, real estate and renting and leasing	305	0	84	14	102	11	348
54 Professional, scientific and technical services	2,813	48	260	32	411	171	3,119
56 Administrative and support, waste management and remediation services	50	1	10	1	11	2	53
61 Education services	5	0	2	0	0	0	3
62 Health care and social assistance	372	1	1	14	48	25	457
71 Arts, entertainment and recreation	4	0	0	0	0	0	4
72 Accommodation and food services	8	0	0	0	2	0	10
81 Other services (except public administration)	37	1	3	1	7	3	44
Business sector	**14,294**	**107**	**636**	**184**	**2,669**	**954**	**17,358**
Non-profit institutions	109	0	4	0	0	3	108
Universities	8,535	0	280	0	0	242	8,497
Provincial government	314	0	10	0	0	8	312
Federal government	1,931	0	63	0	0	139	2,007
Government sector	**10,889**	**0**	**357**	**0**	**0**	**392**	**10,924**
Total business plus government	**25,183**	**107**	**993**	**184**	**2,669**	**1,346**	**28,282**

Appendix 11

Table A.11-1 Research and development supply and use, base case—no profits, 2004

Input/Output industry codes	Research and development produced in Canada	Imports of research and development	Research and development purchased in Canada	Total supply	Domestic sales of research and development	Exports	Fixed capital formation	Total use
	millions of dollars							
1A Crop and animal production	59	0	5	64	1	11	52	64
1B Forestry and logging	4	0	0	4	0	0	4	4
1C Fishing, hunting and trapping	1	0	0	1	0	0	1	1
1D Support activities for agriculture and forestry	32	0	1	33	5	3	25	33
21 Mining and oil and gas extraction	337	92	48	477	1	5	471	477
22 Utilities	165	1	9	175	8	5	162	175
23 Construction	56	0	4	60	0	7	53	60
3A Manufacturing	8,697	818	554	10,069	205	1,506	8,358	10,069
41 Wholesale trade	801	34	118	953	2	281	670	953
4A Retail trade	22	0	4	26	0	2	24	26
4B Transportation and warehousing	39	3	8	50	0	1	49	50
51 Information and cultural industries	1,266	21	44	1,331	5	99	1,227	1,331
5A Finance, insurance, real estate and renting and leasing	246	12	52	310	0	11	299	310
54 Professional, scientific and technical services	2,784	221	148	3,153	107	769	2,277	3,153
56 Administrative and support, waste management and remediation services	43	6	12	61	4	0	57	61
61 Education services	3	2	0	5	0	0	5	5
62 Health care and social assistance	424	54	17	495	53	173	269	495
71 Arts, entertainment and recreation	4	1	0	5	0	0	5	5
72 Accommodation and food services	8	0	0	8	0	6	2	8
81 Other services (except public administration)	38	5	1	44	2	11	31	44
Business sector	**15,029**	**1,270**	**1,025**	**17,324**	**393**	**2,890**	**14,041**	**17,324**
Non-profit institutions	108	0	696	804	70	13	721	804
Universities	8,497	0	0	8,497	4,815	96	3,586	8,497
Provincial government	312	0	1,061	1,373	39	0	1,334	1,373
Federal government	2,007	0	2,591	4,598	56	0	4,542	4,598
Government sector	**10,924**	**0**	**4,348**	**15,272**	**4,980**	**109**	**10,183**	**15,272**
Total business plus government	**25,953**	**1,270**	**5,373**	**32,596**	**5,373**	**2,999**	**24,224**	**32,596**

Appendix 11

Table A.11-2 Research and development supply and use—profits, no premium, 2004

Input/Output Industry codes	Research and development produced in Canada	Imports of research and development	Research and development purchased in Canada	Total supply	Domestic sales of research and development	Exports	Fixed capital formation	Total use
	millions of dollars							
1A Crop and animal production	62	0	5	67	1	11	55	67
1B Forestry and logging	4	0	0	4	0	0	4	4
1C Fishing, hunting and trapping	1	0	0	1	0	0	1	1
1D Support activities for agriculture and forestry	31	0	1	32	5	3	24	32
21 Mining and oil and gas extraction	381	92	48	521	1	5	515	521
22 Utilities	257	1	9	267	8	5	254	267
23 Construction	56	0	4	60	0	7	53	60
3A Manufacturing	8,936	818	554	10,308	205	1,506	8,597	10,308
41 Wholesale trade	847	34	118	999	2	281	716	999
4A Retail trade	20	0	4	24	0	2	22	24
4B Transportation and warehousing	45	3	8	56	0	1	55	56
51 Information and cultural industries	1,540	21	44	1,605	5	99	1,501	1,605
5A Finance, insurance, real estate and renting and leasing	317	12	52	381	0	11	370	381
54 Professional, scientific and technical services	2,819	221	148	3,188	107	769	2,312	3,188
56 Administrative and support, waste management and remediation services	47	6	12	65	4	0	61	65
61 Education services	3	2	0	5	0	0	5	5
62 Health care and social assistance	416	54	17	487	53	173	261	487
71 Arts, entertainment and recreation	4	1	0	5	0	0	5	5
72 Accommodation and food services	10	0	0	10	0	6	4	10
81 Other services (except public administration)	40	5	1	46	2	11	33	46
Business sector	**15,836**	**1,270**	**1,025**	**18,131**	**393**	**2,890**	**14,848**	**18,131**
Non-profit institutions	108	0	696	804	70	13	721	804
Universities	8,497	0	0	8,497	4,815	96	3,586	8,497
Provincial government	312	0	1,061	1,373	39	0	1,334	1,373
Federal government	2,007	0	2,591	4,598	56	0	4,542	4,598
Government sector	**10,924**	**0**	**4,348**	**15,272**	**4,980**	**109**	**10,183**	**15,272**
Total business plus government	**26,760**	**1,270**	**5,373**	**33,403**	**5,373**	**2,999**	**25,031**	**33,403**

Appendix 11

Table A.11-3 Research and development supply and use, profits—5% premium, 2004

Input/Output industry codes		Research and development produced in Canada	Imports of research and development	Research and development purchased in Canada	Total supply	Domestic sales of research and development	Exports	Fixed capital formation	Total use
		millions of dollars							
1A	Crop and animal production	65	0	5	70	1	11	58	70
1B	Forestry and logging	5	0	0	5	0	0	5	5
1C	Fishing, hunting and trapping	1	0	0	1	0	0	1	1
1D	Support activities for agriculture and forestry	32	0	1	33	5	3	25	33
21	Mining and oil and gas extraction	395	92	48	535	1	5	529	535
22	Utilities	269	1	9	279	8	5	266	279
23	Construction	59	0	4	63	0	7	56	63
3A	Manufacturing	9,363	818	554	10,735	205	1,506	9,024	10,735
41	Wholesale trade	886	34	118	1,038	2	281	755	1,038
4A	Retail trade	21	0	4	25	0	2	23	25
4B	Transportation and warehousing	47	3	8	58	0	1	57	58
51	Information and cultural industries	1,608	21	44	1,673	5	99	1,569	1,673
5A	Finance, insurance, real estate and renting and leasing	332	12	52	396	0	11	385	396
54	Professional, scientific and technical services	2,969	221	148	3,338	107	769	2,462	3,338
56	Administrative and support, waste management and remediation services	50	6	12	68	4	0	64	68
61	Education services	3	2	0	5	0	0	5	5
62	Health care and social assistance	436	54	17	507	53	173	281	507
71	Arts, entertainment and recreation	4	1	0	5	0	0	5	5
72	Accommodation and food services	10	0	0	10	0	6	4	10
81	Other services (except public administration)	42	5	1	48	2	11	35	48
Business sector		**16,597**	**1,270**	**1,025**	**18,892**	**393**	**2,890**	**15,609**	**18,892**
Non-profit institutions		108	0	696	804	70	13	721	804
Universities		8,497	0	0	8,497	4,815	96	3,586	8,497
Provincial government		312	0	1,061	1,373	39	0	1,334	1,373
Federal government		2,007	0	2,591	4,598	56	0	4,542	4,598
Government sector		**10,924**	**0**	**4,348**	**15,272**	**4,980**	**109**	**10,183**	**15,272**
Total business plus government		**27,521**	**1,270**	**5,373**	**34,164**	**5,373**	**2,999**	**25,792**	**34,164**

Appendix 11

Table A.11-4 Research and development supply and use, profits—5% premium, 2004

Input/Output Industry codes	Research and development produced in Canada	Imports of research and development	Research and development purchased in Canada	Total supply	Domestic sales of research and development	Exports	Fixed capital formation	Total use
	millions of dollars							
1A Crop and animal production	67	0	5	72	1	11	60	72
1B Forestry and logging	5	0	0	5	0	0	5	5
1C Fishing, hunting and trapping	1	0	0	1	0	0	1	1
1D Support activities for agriculture and forestry	34	0	1	35	5	3	27	35
21 Mining and oil and gas extraction	409	92	48	549	1	5	543	549
22 Utilities	281	1	9	291	8	5	278	291
23 Construction	61	0	4	65	0	7	58	65
3A Manufacturing	9,790	818	554	11,162	205	1,506	9,451	11,162
41 Wholesale trade	925	34	118	1,077	2	281	794	1,077
4A Retail trade	22	0	4	26	0	2	24	26
4B Transportation and warehousing	49	3	8	60	0	1	59	60
51 Information and cultural industries	1,676	21	44	1,741	5	99	1,637	1,741
5A Finance, insurance, real estate and renting and leasing	348	12	52	412	0	11	401	412
54 Professional, scientific and technical services	3,119	221	148	3,488	107	769	2,612	3,488
56 Administrative and support, waste management and remediation services	53	6	12	71	4	0	67	71
61 Education services	3	2	0	5	0	0	5	5
62 Health care and social assistance	457	54	17	528	53	173	302	528
71 Arts, entertainment and recreation	4	1	0	5	0	0	5	5
72 Accommodation and food services	10	0	0	10	0	6	4	10
81 Other services (except public administration)	44	5	1	50	2	11	37	50
Business sector	**17,358**	**1,270**	**1,025**	**19,653**	**393**	**2,890**	**16,370**	**19,653**
Non-profit institutions	108	0	696	804	70	13	721	804
Universities	8,497	0	0	8,497	4,815	96	3,586	8,497
Provincial government	312	0	1,061	1,373	39	0	1,334	1,373
Federal government	2,007	0	2,591	4,598	56	0	4,542	4,598
Government sector	**10,924**	**0**	**4,348**	**15,272**	**4,980**	**109**	**10,183**	**15,272**
Total business plus government	**28,282**	**1,270**	**5,373**	**34,925**	**5,373**	**2,999**	**26,553**	**34,925**

Appendix 12 National occupational classification - Statistics Canada (NOC-S) 2001

A121	Engineering managers
A122	Computer and information systems managers
A123	Architecture and science managers
C011	Physicists and astronomers
C012	Chemists
C013	Geologists, geochemists and geophysicists
C021	Biologists and related scientists
C031	Civil engineers
C032	Mechanical engineers
C033	Electrical and electronics engineers
C034	Chemical engineers
C041	Industrial and manufacturing engineers
C045	Petroleum engineers
C046	Aerospace engineers
C047	Computer engineers (except software engineers)
C048	Other professional engineers, n.e.c.
C061	Mathematicians, statisticians and actuaries
C071	Information systems analysts and consultants
C072	Database analysts and data administrators
C073	Software engineers
C074	Computer programmers and interactive media developers
C075	Web designers and developers
C183	Systems testing technicians
E031	Natural and applied science policy researchers, consultants and program officers
E032	Economists and economic policy researchers and analysts
E033	Business development officers and marketing researchers and consultants
E034	Social policy researchers, consultants and program office
E035	Education policy researchers, consultants and program officers
E111	University professors
E112	Post-secondary teaching and research assistants

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